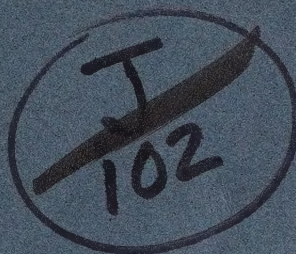
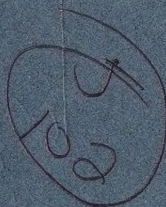


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UNHOLTZ-DICKIE CORPORATION

vibration generation systems and measurement instruments



OPERATING INSTRUCTION MANUAL
MODEL CV608RMG-6

MP MASTER



MA34553

UNHOLTZ-DICKIE CORPORATION

**2994 Whitney Avenue
Hamden, Connecticut 06518**

INSTRUCTION MANUAL

**MODEL CV608RMG-6
DIAL-A-CHARGE or VOLTAGE
VIBRATION MONITORING INSTRUMENT**

APPLICABLE SERIAL NUMBER

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GENERAL DESCRIPTION1.0 Description of Operation

The Model CV608RMG-6 is a six channel, data acquisition instrument designed with modular type amplifiers that plug into a rack mounting frame. Each amplifier module is operable as a charge amplifier or a voltage amplifier. Mode selection is provided by a switch located on the individual module chassis. Any combination of charge and voltage inputs may be selectable on the 6 modules in a single frame. The transducer sensitivity dial calibration on each module applies for either charge or voltage transducers without scale factor correction. Pilot light indication of whether charge or voltage is being measured is provided. The instrument contains four separate outputs in the form of an indicating meter, a normalized 10 pk mv/pk g "servo" output, a variable gain "current" output for galvo recording, and a variable gain "voltage" output for tape recording. The operation of the Model CV608RMG-6 is illustrated by the simplified block diagram in Figure 1.

1.1 Charge Preamplifier

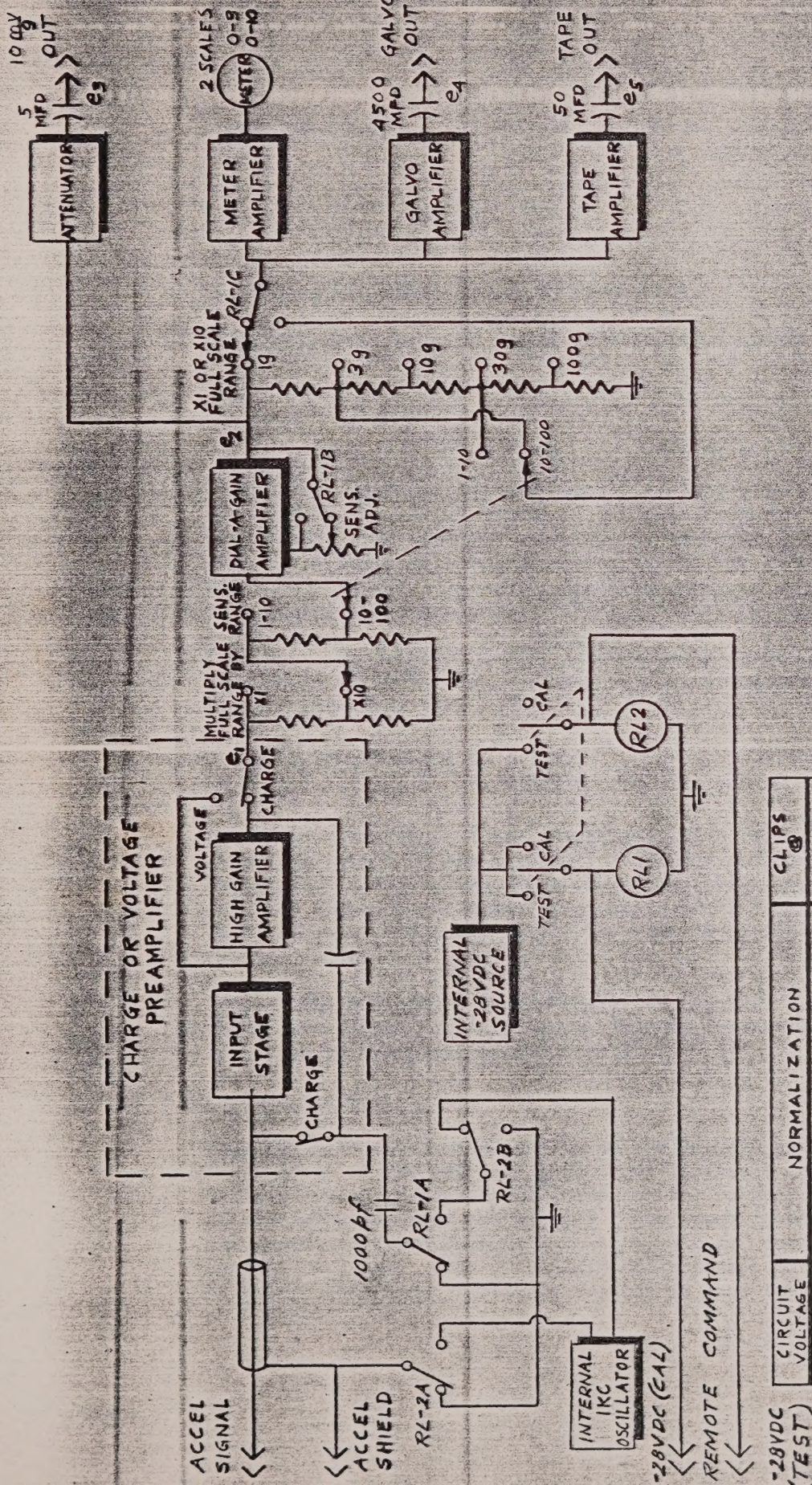
When the mode selector switch is in the CHARGE position, the input stages of the 608 form a special type of feedback amplifier that is intended for use with piezoelectric accelerometers or their equivalent. The input stages provide a high gain (approximately 5000) over a wide band-width (unity gain at approximately 3 mc) and have a capacitor in the feedback path. Since the input coaxial cables and piezoelectric type accelerometers have basically a capacitive impedance, the charge amplifier feedback capacitor and the input capacitors form a voltage divider network. As is the case with operational type amplifier circuits, the output of the charge preamplifier can be expressed as:

$$e_{out} = \frac{Z_{fdbk}}{Z_{source}} e_{in} = \frac{C_{source}}{C_{fdbk}} E_{accel} \quad (1)$$

The voltage sensitivity of a piezoelectric type accelerometer is a function of capacitive loading as:

$$E_{accel} = \frac{C_{accel}}{C_{total}} E_{open \text{ ckt}} \quad (2)$$

Therefore, the output of the charge amplifier increases as the total source capacitance increases, and the voltage sensitivity of the loaded accelerometer decreases as the total load or source capacitance increases. In effect then, the charge amplifier automatically senses the changes in cable loading and provides a constant output that is independent of cable loading.



BLOCK DIAGRAM

UNHOLTZ-DICKIE MODEL 8BPMCV
CHARGE OR VOLTAGE PLUG-IN AMPLIFIER
WITH REMOTE CALIBRATE AND TEST FEATURE

CIRCUIT VOLTAGE	NORMALIZATION	CLIPS @
e1, CHARGE MODE	FIXED AT APPROX. 1 mV/pcmb	60 V PK
e1, VOLTAGE MODE	FIXED AT APPROX. 1 mV/mv	20 V PK
e2	ADJUST TO APPROX. 0.85 VOLTS/g	90 V PK
e3	ADJUST TO EXACTLY 10 mV/g	105 V PK
e4	FULL SCALE VAR. FROM 1.3 TO 10 VPK	10.5 V PK 100 mV PK
e5	FULL SCALE VAR. FROM 0 TO 25 VPK	4 V PK OR 1 ma PK

Combining equations (1) and (2), yields the charge amplifier output:

$$e_{out} = \frac{C_{accel}}{C_{fdbk}} E_{oc} \quad (3)$$

which is independent of cable capacitance.

Since the accelerometer charge sensitivity Q equals $C_{accel} \times E_{oc}$, then:

$$e_{out} = \frac{Q}{C_{fdbk}} \quad (4)$$

which shows that the feedback amplifier output voltage is related directly to the charge output of the accelerometer. If the charge amplifier feedback capacitor is selected to be 1000 pf, then 1 millivolt is produced at the output for 1 picocoulomb of generated charge. For a more detailed analysis of the operation of a charge amplifier, refer to the Appendix in Section 6.

The input impedance of a high gain feedback amplifier (operational) is determined by the open loop gain and the feedback element according to:

$$Z_{in} = \frac{Z_{fdbk}}{A} = \frac{1}{\omega A C_{fdbk}} \quad (5)$$

Therefore, the input of the charge amplifier looks like a large capacitor, which is approximately 5 MFD for the 608 series instruments. A 1% change in the charge amplifier accuracy occurs when the source capacitance is equal to 1% of 5 MFD or 50,000 pf. This represents approximately 1,500 feet of typical low noise coaxial cable.

Because the 608 series charge amplifier has such a wide bandwidth, its closed loop frequency response remains unchanged to 10 kc for source capacitance up to 150,000 pf.

1.2 Voltage Preamplifier

When the mode selector switch is in the VOLTAGE position, the input stage of the 608 is a high input impedance cathode follower which is capable of accepting the output of a wide range of voltage generating transducers. The input impedance of the 608 instrument when operating in the "voltage" mode is 400 megohm shunted by 35 pf. With a typical accelerometer with 1000 pf capacity, this input impedance results in less than 1/2% error at 5 cps.

1.3 Dial-A-Gain Amplifier and 10 mv/g Output

The next stages of amplification consist of a feedback amplifier whose gain is adjusted by varying the amount of feedback. The gain control is located in the feedback circuit in a manner that causes the amplifier gain to be inversely proportional to the setting of the gain control potentiometer. When the gain control of the Dial-A-Gain amplifier is set for low sensitivity inputs, the amplifier gain is high, and when the gain control is set for high sensitivity inputs the amplifier gain is low. Therefore, when an accelerometer charge or voltage sensitivity is set on the dial of the Dial-A-Gain amplifier, the output of the amplifier is a given, normalized value. This normalized output is provided as one of the instrument outputs at a sensitivity of 10 millivolts (pk)/g(pk). This output signal is independent of the meter, tape and galvo range switching.

1.4 Meter Amplifier

The meter amplifier provides the amplification and the full wave rectification necessary to drive the meter movement. The meter circuit is an average responding circuit that is calibrated to indicate the peak value of a sinusoidal input signal. The meter has two scales for full range indications of 1g, 3g, 10g, 30g, and 100g. It should be noted that since the full scale range switch changes the outputs by a constant factor of 3.16 or $\sqrt{10}$ between any two adjacent ranges, the ranges labeled 3 g and 30 g are actually 3.16 and 31.6 respectively.

1.5 Galvanometer Amplifier

This is a transistorized amplifier that provides a variable voltage gain of approximately 0.5 to 15 and is capable of driving a 10 to 70 ohm load to 100 milliamps peak. The galvo amplifier produces a no load voltage of 10 volts peak without clipping. The output is ac coupled through a 4500 MFD capacitor, and the output resistance is less than 1 ohm. This amplifier is capable of driving 0.15 MFD of cable capacitance without affecting the frequency response out to 5 kc.

1.6 Tape Amplifier

This is a transistorized amplifier that provides an independent output suitable for driving tape recorders or other readout devices. The gain is variable, independent of the galvo gain, from a value of 0 to approximately 4.0. The maximum output voltage when the meter is at full scale deflection is 2.5 volts peak. The maximum output current is 1 ma peak. The output is ac coupled through a 50 MFD capacitor, and the output resistance is less than 50 ohms.

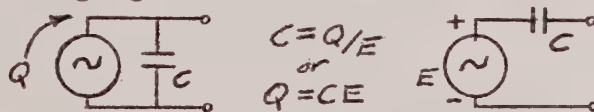
1.7 Random Testing

When this instrument is used for random testing, the clipping levels listed in tabular form in Figure 1 should be used as a guide in setting the front panel controls. The Dial-A-Gain amplifier can be operated up to 300 g random by setting the Full Scale Multiplier Switch in the X10 position. The tape and galvo gain controls should be normalized so that the clipping levels listed in the table will be equal to or greater than 3σ at full scale conditions. The clipping levels of the "charge" or "voltage" preamplifier determine the allowable product of transducer sensitivity and "g" level before 3σ clipping occurs at the input stage.

1.8 Module Calibration in the Charge Mode

1.8.1 Local

When operating in the charge mode, the complete performance of the module can be checked by applying an oscillator voltage to the rear mounted ACCEL IN BNC connector through an externally connected 1000 pf capacitor. The 1000 pf capacitor converts the oscillator output voltage in millivolts to a charge in picocoulombs, thereby effectively making the oscillator a charge generator. This is based on the equivalence of a charge generator and voltage generator as shown below:



When the module is calibrated by using an external 1000 pf capacitor in series with the accelerometer input connector, all of the controls perform their normal function and the input signal can simulate operation at any frequency and input signal level.

An internal calibration feature is provided that will produce full scale outputs when the front panel momentary contact CAL/NORM/TEST switch is held in the CAL position. When this switch is placed in the CAL position, an internally generated 1KC signal is applied through an internal precision 1000 pf capacitor to the input of the charge amplifier. The output signal is independent of the sensitivity and full scale range settings. With this full scale signal applied, the TAPE and GALV gain controls can be adjusted to provide the proper recording levels.

1.8.2 Remote

The module can be switched remotely to the CAL mode by the application of an external -28VDC Command Signal to pin A of the rear mounted remote command connector (paragraphs 2.3.5). All six channels in the rack frame assembly are switched to the CAL mode simultaneously when the proper remote command signal is applied. The command current requirement is approximately 30 ma per module, or a total of approximately 180 ma for all six channels.

1.9 System Check in the Charge Mode

1.9.1 Local

When the front panel momentary contact CAL/NORM/TEST switch is held in the TEST position, the internally generated 1KC signal is applied to the return side of the input cable. The equivalent charge generated is determined by the amount of accelerometer plus cable, or source, capacitance. The 1KC signal amplitude is selected to produce 50% of full scale output for a source capacitance of 3800 pf. A larger source capacitance will produce a proportionately larger output signal, and a smaller source capacitance will produce a proportionately smaller output signal. Changes in the source capacitance due to open circuit or short circuit conditions will be indicated by a change in the module output from the expected reading.

1.9.2 Remote

The module can be switched remotely to the TEST mode by the application of an external -28VDC Command Signal simultaneously to pins A and C of the rear mounted remote command connector (paragraph 2.3.5). All six channels in the rack frame assembly are switched to the TEST mode when the proper remote command signal is applied. The command current requirement is approximately 60 ma per module, or a total of approximately 360 ma for all six channels.

1.10 Module Calibration in the Voltage Mode

1.10.1 Local

When operating in the voltage mode, the complete performance of the module can be checked by applying an

oscillator voltage directly to the rear mounted ACCEL IN BNC connector. When this procedure is used, the oscillator must be disconnected from the ACCEL IN connector before the module is switched back to the charge mode of operation.

If a quick operational check of the module, input cables, and recording levels is required when the module is operating in the voltage mode, a minor modification will permit use of the insertion technique provided by the TEST position. When the CAL/NORM/TEST momentary contact switch is placed in the TEST position, the internally generated 1KC signal is applied to the voltage amplifier input stage through the combined cable and accelerometer capacitance. By interchanging the oscillator signal levels that are applied to the TEST relay, a full scale output signal level is generated that is independent of the sensitivity and full scale range settings. When this voltage insertion technique is used in the voltage mode of operation, the capacitive voltage divider effect of the nominal 10 pf input capacitance on the combined cable and accelerometer capacitance will reduce the output signal from its full scale value by a factor dependent upon the amount of source capacitance. For example, if the combined accelerometer and cable capacitance is 1000 pf, about a 1% reduction from full scale output occurs. Larger values of source capacitance will decrease the attenuation factor, and smaller values of source capacitance will increase the attenuation factor.

1.10.2 Remote

The module can be switched remotely for quick operational checks when it is operating in the voltage mode by application of an external -28VDC command signal simultaneously to pins A and C of the rear mounted remote command connector (paragraph 2.3.5). All six channels in the rack frame assembly are switched to the TEST mode when the proper remote command signal is applied. The command current requirement is approximately 60 ma per module, or a total of approximately 360 ma for all six channels. A nominal full scale output will be produced if the minor modification described in paragraph 1.10.1 is made.

1.11 Internal Calibration Source

An internal oscillator signal of fixed frequency and fixed

Section 1

amplitude is supplied to all six channels. The signal frequency is 1KC and is at a level of approximately 246 mv rms for the CAL input and at a level of approximately 33 mv rms for the TEST input. The oscillator amplitude is stable within $\pm 1\%$ over the operating temperature range 0°C to 50°C , and has less than 1% distortion.

2.0 Description of Controls

2.1 Module Front Panel Controls - Reference Figure 2

2.1.1 Sensitivity Range Switch - (1-10), (10-100)

This two position rotary switch establishes the location of the decimal point in the sensitivity number read from the Sensitivity Dial. For shock testing, the full scale range of the instrument can be extended up to 10,000 g by using an accelerometer with a sensitivity in the 1-10 range and placing the Sensitivity Range Switch in the 10-100 range.

2.1.2 Sensitivity Dial

This ten turn dial is calibrated in terms of transducer sensitivity, and is equipped with a locking brake.

2.1.3 Full Scale Range (g) Switch

This five position rotary switch determines the acceleration level represented by the full scale deflection of the meter. This range switch also changes the tape and galvo outputs, but does not affect the 10 mv/g output.

2.1.4 Full Scale Multiplier Switch - (X1, X10)

This two position toggle switch indicates the multiplier that applies to the FULL SCALE RANGE (g) Switch reading. This switch attenuates all of the outputs by a factor of 10 when it is in the X10 position.

2.1.5 GALV GAIN Control

This ten turn potentiometer varies the galvanometer amplifier gain over a dynamic range of approximately 30 to 1. The turns counting dial is equipped with a locking brake. This gain control is independent of the tape gain control.

2.1.6 TAPE GAIN Control

The ten turn potentiometer varies the tape amplifier output from 0 to 100% of maximum output. The turns counting dial is equipped with a locking brake. This gain control is independent of the galvo gain control.



Figure 2.

2.1.7 CAL/NORM/TEST Momentary Contact Switch

This three position momentary contact switch is spring loaded in the center or NORM position. In the NORM position the accelerometer input only is connected to the charge amplifier input stage to provide for normal operation. When the remote -28VDC command signals are applied to the instrument with the front panel switch in the NORM position, and with the module operating in the charge mode, either of the CAL or TEST functions can be selected remotely by proper application of the command signals (see paragraph 2.3.5). Local selection of the CAL mode is obtained by holding the CAL/NORM/TEST switch in the up or CAL position. In the CAL position, a fixed 1KC internal oscillator signal provides full scale output signal levels that are independent of the sensitivity and full scale range settings. Local selection of the TEST mode is obtained by holding the CAL/NORM/TEST switch in the down or TEST position. In the TEST position, another fixed 1KC internal oscillator signal is applied through the combined cable and accelerometer capacitance to the charge amplifier input stage. For 3800 pf source capacitance, a 50% full scale output is obtained.

In the voltage mode of operation, the CAL position is inoperable. The TEST position can be used in the voltage mode of operation to provide a quick operational check. Under this condition the 1KC oscillator signal is applied to the voltage amplifier input stage through the source capacitance. Nominal full scale output signal levels can be obtained, if required, by interchanging the two 1KC internal oscillator signals at the TEST relay.

2.2 Module Chassis Controls

2.2.1 CHARGE, VOLTAGE Mode Selector

This two position slide switch, located on top of the module chassis near the center, selects the mode of operation as a charge amplifier input or as a high impedance cathode follower input. The down position is the "charge" mode and the up position is the "voltage" mode. The "charge" or "voltage" mode selection is made by removing the plug-in module from the frame assembly. This procedure prevents accidental change of the mode of operation, and insures that switching takes place when the power is removed from the module. The CHARGE and VOLTAGE front panel.

pilot lights indicate the mode of operation that is in use.

2.2.2 ACCELERATION ADJUST

This 25 turn trimpot is located on top of the module chassis toward the front, and its screwdriver slot is surrounded by a circular, hollow guide to facilitate adjustment. The ACCELERATION ADJUST potentiometer normalizes the 10 mv/g output. This gain adjustment should be made before the meter gain adjustment is made. The slotted shaft may be sighted and reached through an access hole provided in the top cover of the frame assembly. The blade of the adjusting device should be less than 0.110 inches wide.

2.2.3 METER ADJUST

This 25 turn trimpot is located on top of the module chassis toward the middle, and its screwdriver slot is surrounded by a circular, hollow guide to facilitate adjustment. This potentiometer normalizes the meter reading. The meter gain adjustment should be made after the 10 mv/g gain adjustment has been made. Since the meter sensitivity is slightly dependent upon its location relative to the meters of the other channels, the meter calibration should be determined when all the modules are in their proper channel location. The slotted shaft may be sighted and reached through an access hole provided in the top cover of the frame assembly. The blade of the adjusting device should be less than 0.110 inches wide.

2.3 Instrument Rear Panel Connectors

2.3.1 Accelerometer Input Connector

Each channel is equipped with a BNC connector for the accelerometer input. The BNC connector can be converted for use with low noise Microdot type cable with a Microdot 33-101 adapter. This adapter is not supplied with the instrument.

2.3.2 Output Connectors

Each channel is equipped with three separate BNC connectors for each of the three outputs:

TAPE OUT - BNC
GALV OUT - BNC
SERVO OUT - BNC

2.3.3 Chassis Ground Strap

A removable shorting link is provided at the rear of the power supply to connect the signal ground to the chassis. If it is desired, the signal ground can be connected elsewhere in the system installation by removing the shorting link.

2.3.4 Power Supply Output

The 290 VDC power supply output is available at the test point located at the rear of the power supply.

2.3.5 Remote Command Signals

The -28VDC remote command signals are applied to a rear mounted type MS3102A-10SL-3P connector. The pin allocations are:

PIN A - negative 28VDC (See below)
PIN B - circuit ground
PIN C - negative 28VDC (See below)

To place the instrument in the CAL mode remotely, apply -28VDC to PIN A. To place the instrument in the TEST mode remotely, apply -28VDC to both PIN A and PIN C. The CAL mode command requires 30 ma per channel or 180 ma for 6 channels. The TEST mode command requires 60 ma per channel or 360 ma for 6 channels.

OPERATING INSTRUCTIONS1.0 Charge Mode of Operation

In order to operate in the "charge" mode, the slide switch located on top of the module chassis near the center must be in the down position as indicated by the labeling. It is suggested that each module to be operated in the "charge" mode that has previously been operating in the voltage mode, be removed from the frame assembly, switched to the "charge" mode, and then returned to its same channel location before power is applied to the instrument.

1.1 Setup and Operating Procedure Using a Shaker

- 1.1.1 Connect the accelerometers to the channels to be used.

Only piezoelectric type transducers should be connected to the input since the charge amplifier will not function properly with a resistive source connected to its input. For minimum ground loop pickup the accelerometers must be isolated from ground at the mounting location by using isolating studs or an equivalent technique. Also, use of the TEST feature of this instrument requires that the return side of the accelerometer and cable be isolated from ground so that an internal oscillator signal can be inserted at this point. See Section 1, Paragraph 2.3.1 for converting the accelerometer BNC input connection for use with low noise Micro-dot type cable.

- 1.1.2 Connect the tape, galvo, and 10 mv/g outputs to the readout or control equipment as required.
- 1.1.3 Set the Sensitivity Range Switch in the 1-10 or 10-100 position as determined by the charge sensitivity of the accelerometer used with each particular channel. The units are pk-pcmb/pk-g.
- 1.1.4 Rotate the multiturn Sensitivity Dial until the numerical readout on the dial corresponds to the first three places of the accelerometer charge sensitivity. Lock the dial in position.
- 1.1.5 The CAL/NORM/TEST switch remains in the NORM position.
- 1.1.6 Set the FULL SCALE RANGE (g) Switch for the expected vibration level.

- 1.1.7 Set the Full Scale Multiplier Switch in the XI position unless the full scale vibration levels to be measured are 300 g or 1000 g, in which case set the switch in the X10 position.

Important: If the 10mv/g output is being used for automatic shaker control, the Full Scale Multiplier Switch must be in the XI position. When this switch is in the X10 position, the 10mv/g output is converted to a 1 mv/g output.

- 1.1.8 Apply power to the instrument, and check that the "charge" mode indicator lights are energized for the proper channels. Allow several minutes for warmup.
- 1.1.9 Adjustment of the TAPE GAIN and/or GALV GAIN controls to provide the proper recording level can be accomplished for all the channels at one time by operating the shaker at some low frequency where the specimen acts as a rigid body and all accelerometers see the same motion. The "g" level can be determined by reading the meters or by monitoring the 10 mv/g output. When the shaker motion has been set to the desired "g" level, rotate the TAPE and/or GALV controls until the desired recording levels have been obtained. Lock the dials in position.
- 1.1.10 Change the FULL SCALE RANGE Switch as required to maintain the best recording levels.

Note: The FULL SCALE RANGE Switch changes the outputs by a constant factor of 3.16 or $\sqrt{10}$ between any two adjacent ranges, therefore, the full scale ranges labeled 3 and 30 are actually 3.16 and 31.6 respectively.

1.2 Setup Procedure Using the Fixed Calibration Feature

Full scale output level for checking the settings of the output amplifier gain controls is readily obtained by using the "fixed calibration" feature. The full scale output condition can be commanded remotely or selected locally at the individual modules.

1.2.1 Fixed Calibration by Remote Control

- 1.2.1.1 Apply power to the instrument and check that the "charge" mode indicator lights are energized for the proper channels. Allow several minutes for warmup.

1.2.1.2 Set the Full Scale Multiplier Switch in the X1 position.

1.2.1.3 Apply the -28VDC command signal to the MS3102A-10SL-3P connector located at the rear of the instrument. Refer to section 1, paragraph 2.3.5 for pin connections and current requirements.

1.2.1.4 Adjust the TAPE GAIN and/or GALV GAIN controls to provide the proper recording levels.

1.2.2 Fixed Calibration by Local Control

1.2.2.1 Follow the same procedure as above except that the momentary contact CAL/NORM/TEST Switch is held in the CAL, or up, position instead of applying an external command signal.

1.3 Test of Input Cable and Accelerometer Condition

A check of the input cable, accelerometer, and connector operational conditions can be obtained when operating in the charge mode by inserting the internal oscillator signal in the return side of the input cable. This insertion technique effectively provides a measure of the source capacitance. Any change in the source capacitance due to opens or shorts will be indicated by a change in the 608 output from the expected reading.

The level of the fixed internal oscillator signal has been selected so that a source capacitance of 3800 pf will produce an output signal equal to 50% of full scale value. A larger source capacitance will produce a proportionately larger output signal, and a smaller source capacitance will produce a proportionately smaller output signal.

1.3.1 Test of Source Capacitance by Remote Control

1.3.1.1 Connect the input accelerometer according to the procedures of paragraph 1.1.1.

1.3.1.2 Set the Full Scale Multiplier Switch in the X1 position.

1.3.1.3 Apply power to the instrument and check that the "charge" mode indicator lights are energized for the proper channels. Allow several minutes for warmup.

Section 2

- 1.3.1.4 Apply the -28VDC command signals to the MS3102A-10SL-3P connector located at the rear of the instrument. Refer to Section 1, paragraph 2.3.5 for pin connections and current requirements.
 - 1.3.1.5 The output signal level should be 50% of full scale if the source capacitance is 3800 pf. Other values of source capacitance will produce proportionate output signal levels unless open circuit or short circuit conditions occur at the input.
- 1.3.2 Test of Source Capacitance by Local Control
- 1.3.2.1 Follow the same procedures as above except that the momentary contact CAL/NORM/TEST Switch is held in the TEST, or down, position instead of applying an external command signal.

2.0 Voltage Mode of Operation

In order to operate in the "voltage" mode, the slide switch located on top of the module chassis near the center must be in the up position as indicated by the labeling. It is suggested that each module to be operated in the "voltage" mode that has previously been operating in the "charge" mode, be removed from the frame assembly, switched to the "voltage" mode, and then returned to its same channel location before power is applied to the instrument.

2.1 Setup and Operating Procedure Using a Shaker

- 2.1.1 Connect the accelerometers to the channels to be used. For minimum ground loop pickup the accelerometers must be isolated from ground at the mounting location by using isolating studs or an equivalent technique. Also, use of the TEST feature for instrument calibration checks requires that the return side of the accelerometer and cable be isolated from ground so that an external oscillator signal can be inserted at this point. See Section 1, Paragraph 2.3.1 for converting the accelerometer BNC input connector for use with low noise Microdot type cable.
- 2.1.2 Connect the tape, galvo, and 10 mv/g outputs to the readout and control equipment as required. See Section 1, Paragraph 2.3.2 for the output connector pin allocations.
- 2.1.3 Set the Sensitivity Range Switch in the 1-10 or 10-100 position as determined by the voltage sensitivity of the combined accelerometer and cable used with each particular channel. The units are pk-mv/pk-g. The voltage sensitivity can be calculated as follows:

$$E_s = E_{oc} \frac{C_a}{C_a + C_c + C_1}$$

where E_s = combined accelerometer plus cable voltage sensitivity

E_{oc} = the accelerometer open circuit voltage sensitivity

C_a = accelerometer capacitance

C_c = cable capacitance

C_1 = 35 pf = 608 input capacitance

If the accelerometer calibration is given for the case of an external cable capacitance loading, the open circuit sensitivity is calculated as follows:

$$E_{oc} = E_{cal} \frac{C_a + C_e}{C_a}$$

where E_{cal} = accelerometer voltage calibration
 C_e = external capacitance used for calibration

- 2.1.4 Rotate the multiturn Sensitivity Dial until the numerical readout on the dial corresponds to the first three places of the combined accelerometer plus cable voltage sensitivity. Lock the dial in position.
- 2.1.5 The CAL/NORM/TEST Switch remains in the NORM position.
- 2.1.6 Set the FULL SCALE RANGE (g) Switch for the expected vibration level.
- 2.1.7 Set the FULL SCALE Multiplier Switch in the X1 position unless the full scale vibration levels to be measured are 300 g and 1000 g, in which case set the switch in the X10 position.
- Important: If the 10 mv/g output is being used for automatic shaker control, the Full Scale Multiplier Switch must be in the X1 position. When the Switch is in the X10 position, the 10 mv/g output is converted to a 1 mv/g output.
- 2.1.8 Apply power to the instrument, and check that the "voltage" mode indicator lights are energized for the proper channels. Allow several minutes for warmup.
- 2.1.9 Adjustment of the TAPE GAIN and/or GALV GAIN controls to provide the proper recording level can be accomplished for all the channels at one time by operating the shaker at some low frequency where the specimen acts as a rigid body and all accelerometers see the same motion. The "g" level can be determined by reading the meters or by monitoring the 10 mv/g output. When the shaker motion has been set to the desired "g" level, rotate the TAPE and/or GALV controls until the desired recording levels have been obtained. Lock the dials in position.
- 2.1.10 Change the FULL SCALE RANGE Switch as required to maintain the best recording levels.

Note: The FULL SCALE RANGE Switch changes the outputs by a constant factor of 3.16 or $\sqrt{10}$ between any two adjacent ranges, therefore, the full scale ranges labeled 3 and 30 are actually 3.16 and 31.6 respectively.

2.2 Setup Procedure Using a Calibrating Oscillator

If it is impractical to vibrate the specimen during setup or if the accelerometers are not all vibrating at the same level due to resonances, alternate methods of setting the gain controls may be used.

2.2.1 Fixed Calibration by Remote Control

If the modules are to be used in the voltage mode for an extended period of time, a quick full scale check can be obtained by making a minor wiring change at the TEST relay (RL2 on dwg 9105419). The modification requires that the two signals from the fixed oscillator (pins 17 and 19) be interchanged at the relay RL2 terminals. Relay RL2 is located nearest the rear of the module.

2.2.1.1 Connect the input cables as in paragraph 2.1.1.

2.2.1.2 Apply power to the instrument and check that the "voltage" mode indicator lights are energized for the proper channels. Allow several minutes for warmup.

2.2.1.3 Set the Full Scale Multiplier Switch in the X1 position.

2.2.1.4 Apply the -28VDC command signal to the MS3102A-10SL-3P connector located at the rear of the instrument. Refer to Section 1, paragraph 2.3.5 for pin connections and current requirements.

2.2.1.5 Adjust the TAPE GAIN and/or GALV GAIN controls to provide the proper recording levels. Note that since the input capacitance of the first stage is approximately 10 pf, the attenuation due to the capacitive voltage divider action is about 1% when the source capacitance is 1000 pf. Larger values of source capacitance will cause less than 1% attenuation.

2.2.2 Fixed Calibration by Local Control.

2.2.2.1 Follow the same procedure as above except that

2.2.2.1 contd.

momentary contact CAL/NORM/TEST Switch is held in the TEST, or down, position instead of applying an external command signal.

2.2.3 Variable Calibration, Combined Remote and Local

A quick check calibration can be obtained without any modifications by compensating for the reduced, fixed oscillator signal level with readjustment of the Sensitivity Dial.

2.2.3.1 Follow the same procedure as in 2.2.1 except apply the -28VDC remote command signal to pin C of the rear mounted connector. This procedure makes the output dependent upon the sensitivity and range controls.

2.2.3.2 Set the Full Scale Range Switch, the Sensitivity Range Switch, and the Sensitivity Dial to produce full scale output as determined by monitoring the 10 mv/g normalized output.

2.2.4 Variable Calibration by Local Control

The calibration accuracy of any channel can be checked by connecting the oscillator directly to the "accelerometer input" connector of that channel. Adjust the oscillator output voltage in millivolts peak to equal the product of the accelerometer sensitivity in pk-mv/pk-g and the "g" level to be simulated. After completion of this calibration check be sure to disconnect the oscillator from the accelerometer input connector, particularly if the module is to be switched to the "charge" mode of operation.

MAINTENANCE

1.0 Spare Parts List

1.1 Fuses

1.1.1 290 VDC Power Supply - F1

3/10 amp, fast acting - Bussman Type AGC 3/10

Particular attention is called to the type of fuse used in the 290 VDC transistorized power supply. A conventional, fast acting, 3/10 amp. Buss type AGC fuse is used. This fuse is the best compromise between the fast action required during a shorting condition and the continuous operation required at full load, high ambient operating conditions. If the 290 V supply should be shorted, and Buss type AGC 3/10 amp. fuses are not on hand, do not use a larger or slower acting fuse. Buss type AGC 1/4 amp. fuses may be used temporarily for approximately 8 hour periods when the supply is operating 6 type 8PMCV modules. If the supply is operating 6 type 8PCV or 8PXC modules, or less than 6 type 8PMCV modules, a 1/4 amp fuse can be used for continuous operation.

1.1.2 6VDC Filament Supply - F2

4 amp, slo blow - Bussman type MDX 4

1.1.3 AC Power - F3

3 amp, slo blow - Bussman type MDX3

1.2 Transistors

2N1377 - Texas Instruments
2N1545 - Motorola
154-20 - Westinghouse
2N1022 - Texas Instruments
2N657 - General Electric
2N699 - RCA
2N2156 - Motorola

1.3 Diodes

SM240 - Semicon
IN3122 - Amperex
ZD100A - Diodes, Inc.
ZD30B - Diodes, Inc.
ZD3.9A - Diodes, Inc.
DI 45 - Diodes, Inc.
IN100 - Transitron
ZD20B - Diodes, Inc.

IN2842RB- Motorola
IN936 Motorola
IN3040A - Motorola
IN3828A - Motorola
IN3013B - International Rectifier
IN3015B - International Rectifier
IN1096 - General Electric
IN1342A - General Electric

1.4 Nuvistors

7895 - Nuvistor - RCA
7587 - Nuvistor - RCA

2.0 Voltage Charts

2.1 8 PMCV Module - Schematic Dwg. 9104936

Location (Charge Mode)	Typical DC Voltage	Location (Charge Mode)	Typical DC Voltage
V1 plate	90 to 110	V8 cathode	3 to 4.5
V1 cathode	20 to 35	V9 plate	100 to 120
V2 plate	80 to 130	V9 cathode	1.3 to 1.7
V3 plate	90 to 130	V10 cathode	70 to 90
V3 screen	35 to 50	V11 plate	90 to 110
V3 cathode	.75 to .85	V11 cathode	40 to 55
V4 cathode	90 to 130	V12 cathode	35 to 50
V5 plate	95 to 145	Q1 collector	-10 to -15
V6 plate	115 to 145	Q2 collector	-24 to -27
V6 screen	35 to 50	Q4 base	-2.6 to -3.2
V6 cathode	2.1 to 2.5	Q4 collector	-10 to -15
V7 cathode	120 to 155	Q5 collector	-7 to -9
V8 plate	200 to 235	Q5 base	-9 to -1.1
V8 screen	60 to 75	Q6 emitter	-7 to -9

2.2 608 Power Supply - Schematic Dwg. 9105433

Location	Typical DC Voltage	Location	Typical DC Voltage
Output Test Point	285 to 295	Q2 base	295 to 405
Q4 & Q5 emitter	165 to 180	Q1 collector	305 to 415
Q5 collector	185 to 205	Q6 emitter	-5.8 to -6.4
Q4 collector	185 to 205	Q6 collector	-8 to -11
Q3 emitter	185 to 205	C9 thru C11	-40 to -50
Q3 collector	210 to 230	C12 thru C14	-40 to -50
Q2 collector	285 to 295	AC input	105 to 125

SPECIFICATION

MODEL CV608RMG-6 CHARGE OR VOLTAGE AMPLIFIER

GENERAL

This specification applies to a six channel, data acquisition instrument designed with modular type amplifiers that plug into a rack mounting frame. Each amplifier module shall be operable as a charge amplifier or a voltage amplifier. Mode selection shall be provided by a switch located on the individual module chassis. Any combination of charge and voltage inputs shall be selectable on the 6 modules in a single frame. The transducer sensitivity dial calibration on each module shall apply for either charge or voltage transducers without scale factor correction. Pilot light indication of whether charge or voltage is being measured shall be provided. The instrument shall provide four separate outputs in the form of a peak indicating meter, a normalized 10 pk mv/pk g "servo" output, a variable gain "current" output for galvo recording, and a variable gain "voltage" output for tape recording.

SPECIFICATIONS1.0 Input Characteristic1.1 Charge Mode

All input characteristics when operating in the charge mode shall apply regardless of the instrument gain control and range control settings.

- 1.1.1 The instrument shall be capable of providing full scale outputs of Para. 3.0 while operating with any source capacitance up to 150,000 pf and remain within the frequency response specification between 5 cps and 10 kc, for any transducer sensitivity between 1 and 100 picocoulombs/g.
- 1.1.2 The instrument shall be capable of monitoring up to 1000 g for transducer sensitivities up to 50 picocoulombs/g and up to 10,000 g for transducer sensitivities up to 5 picocoulombs/g.
- 1.1.3 The instrument accuracy shall change by no more than 1% for each 50,000 pf of source capacitance.
- 1.1.4 The input impedance shall be at least 400 megohm resistive and 5 microfarad capacitive.
- 1.1.5 A small pilot light shall indicate when the module is in the charge mode of operation.

1.2 Voltage Mode

- 1.2.1 The input impedance shall be at least 400 megohm resistive and less than 35 pf capacitive.
- 1.2.2 The instrument shall be capable of operating with any voltage input up to 15 volts rms with transducers in the sensitivity range of 1 to 100 pk mv/pk g.
- 1.2.3 A small pilot light shall indicate when the module is in the voltage mode of operation.

2.0 Gain Ranges

- 2.1 The full scale output range of the instrument as indicated by the "Output Range" selector switch shall not be dependent upon the sensitivity range of the transducer that is connected to the instrument input. Full scale output ranges of 1, 3, 10, 30, 100, 300 and 1000 g shall be provided and usable with any transducer sensitivity from 1 to 50 (pcmb or mv)/g. Ranges up to 300 g shall be usable with any transducer from 1 to 100 (pcmb or mv)/g. The range factors shall be accurate within $\pm 1\%$.
- 2.2 A ten turn, lockable, calibrated dial shall provide continuous gain adjustment for transducer sensitivities in the ranges of 1-10, and 10-100 (pcmb or mv)/g. The dial shall indicate to three places the charge or voltage sensitivity of the input signal. The normalized instrument outputs and the meter shall be within $\pm 1\%$ calibration when the dial setting corresponds to the input transducer sensitivity. A transducer sensitivity selector switch shall indicate whether the 10 turn sensitivity dial is in the 1-10 or 10-100 sensitivity range.
- 2.3 For shock testing, the instrument shall be usable in the charge mode to handle inputs up to 10,000 g full scale with transducer sensitivities up to 5 picocoulombs/g.

3.0 Outputs

Four separate simultaneous outputs shall be provided as follows:

3.1 Tape or "Voltage" Output

- 3.1.1 A tape or "voltage" output shall provide a maximum linear, full scale output of ± 2.5 volts peak on any range from 1 g to 1000 g and with any transducer sensitivity from 1 to 100 (pcmb or mv)/g when operating into a 2.5 K ohm load impedance or greater.
- 3.1.2 The maximum, full scale output shall be continuously variable from ± 2.5 volts peak to zero with a 10 turn,

lockable dial. The dial shall be the turns counting type that is readable to 3 places so that desired recording levels can be easily reset. The setting of this dial shall not vary any other output.

3.1.3 The output impedance shall be less than 50 ohms in series with a 50 MFD capacitor.

3.1.4 The output shall be single ended with one side connected to circuit ground.

3.2 Galvo or "Current" Output

3.2.1 A galvo or "current" output shall provide a maximum, linear, full scale output of ± 10 volts peak, when operating into a 2.5 K ohm load impedance or greater. This output shall provide a maximum, linear, full scale output of 85 ma peak into a 10 to 70 ohm load. Full scale output shall be available on any range from 1 g to 1000 g and with any transducer sensitivity from 1 to 100 (pcmb or mv)/g.

3.2.2 The maximum full scale output shall be continuously variable over a 30:1 dynamic range with a 10 turn, lockable dial. The dial shall be the turns counting type that is readable to 3 places. The setting of this dial shall not vary any other output.

3.2.3 The output impedance shall be less than 1 ohm in series with a 4000 MFD capacitor.

3.2.4 The output shall be capable of driving 50,000 pF cable capacitance and remain within the frequency response specification of paragraph 4.2 between 5 cps and 5 kc.

3.2.5 The output shall be single ended with one side connected to circuit ground.

3.3 10 mv/g or "Servo" Output

3.3.1 A normalized output at a sensitivity of 10 pk mv/pk g shall be provided for use with any shaker system servo. This output shall have a calibration accuracy within $\pm 2\%$ at a nominal frequency of 500 cps when the transducer sensitivity dial is set at the correct input signal sensitivity anywhere in the range of 1-100(pcmb or mv)/g. No other gain adjustment shall be required.

3.3.2 This output shall remain at the normalized sensitivity of 10 mv/g for any input level up to 100 g. The

10 mv/g output shall not be affected by the Full Scale Range Switch setting.

3.3.3 The output impedance shall be less than 400 ohms in series with a 5 MFD capacitor.

3.3.4 The output shall be single ended with one side connected to circuit ground.

3.4 Meter Indication

3.4.1 A meter indication of the peak g level shall be provided. The meter circuit shall be the average responding type that is calibrated to indicate the peak value of a sine wave.

3.4.2 The meter indication shall be accurate within $\pm 2\%$ of the full scale reading, at a nominal frequency of 500 cps when the sensitivity dial of 2.2 is set to the numerical value of the sensitivity of the transducer attached to the input. The basic meter movement shall be linear within $\pm 1\%$ of full scale. The scale length shall be at least $2\frac{1}{2}$ inches, and shall be readable within $\pm 1\%$ of full scale.

3.4.3 The meter shall have two scales for direct indication in the 0 to 10 and the 0 to 3 ranges. The 0 to 10 range shall have 50 divisions, and the 0 to 3 range shall have 30 divisions. The full scale Output Range switch shall indicate directly which meter scale is in use without reference to the sensitivity of the input transducer.

4.0 Frequency Response

4.1 The tape, meter and 10 mv/g outputs shall be flat within $\pm 1\%$ from 10 cps to 5 kc, and within $\pm 2\%$ from 5 cps to 10 kc.

4.2 The galvo output shall be flat within $\pm 1\%$ from 10 cps to 2 kc and $\pm 5\%$ from 3 cps to 5 kc.

5.0 Hum and Noise

5.1 Charge Mode

TRANSDUCER SENSITIVITY	SOURCE CAPACITANCE	SOURCE CAPACITANCE
	4,000 pf (100 ft. cable + typ. accel.)	50,000 pf (1600 ft. cable + typ. accel.)
7 pk pcmb/pk g	1.0% of 1 g full scale <0.5% higher ranges	3.0% of 3 g full scale 1.0% of 10g full scale <0.5% higher ranges
15 pk pcmb/pk g	0.7% of 1 g full scale <0.5% higher ranges	1.5% of 3 g full scale <0.5% higher ranges

5.2 Voltage Mode

TRANSDUCER SENSITIVITY	10 ft. low noise coax cable with typical 1000 pf accel.	40 ft. low noise coax cable with same accel. & sensitivity readjusted
10 pk mv/pk g	<0.5% of 1 g full scale and higher ranges	1.0% of 1 g full scale <0.5% higher ranges

6.0 Calibrate and Test Functions

6.1 Instrument Calibration & Normalization

Provision for inserting a signal at the input to allow checking the calibration of each channel shall be provided. In addition this signal may be used to adjust the tape and galvo outputs to the desired recording levels. Since a calibrating charge generator is not readily available a precision series capacitor of 1000 pf $\pm 1\%$ shall be provided in each channel to convert a voltage calibrating signal in millivolts to a charge signal in picocoulombs. The calibrating signal shall be front panel selectable on any or all channels from a single calibrating source.

6.2 Instrument System Calibration & Check

The return side of the input cable and accelerometer of any or all of the instrument channels shall be capable of being switched to the single external oscillator of 6.1 for test of the cable, accelerometer, and connector operational conditions. Comparison of the reading in this connection with the reading in 6.1 shall provide a direct measure of the source capacitance. Any change in source capacitance due to opens or shorts shall be indicated by a change in the reading obtained.

6.3 Voltage Amplifier Calibration Check

When the amplifier is operated in the voltage mode it shall be possible to calibrate the complete channel including the accelerometer, cable and amplifier by connecting the calibrate signal in series with the return side of the input cable as in 6.2 and adjusting the calibrate signal to the voltage sensitivity of the accelerometer and cable being used.

7.0 Stability

7.1 The warmup period required for stable calibration shall be less than 15 minutes.

7.2 Gain change for line voltage variations from 105 to 125 volts ac, and for temperatures variation over the range of 40°F to 125°F shall be less than $\pm 2\%$.

8.0 Amplitude Linearity

The tape, galvo, and 10 mv/g outputs shall be linear within $\pm 1\%$ of the best straight line approximation of the output amplitude versus the input amplitude.

9.0 Recovery from Overload

Recovery shall be instantaneous for an overload pulse of 1 millisecond duration and 10 times full scale amplitude for any input level up to 55,000 pcmb.

10.0 Cross Channel Modulation

There shall be less than 0.1% cross channel modulation between any two channels for any full scale range.

11.0 Grounding

11.1 Provisions shall be made to connect circuit ground to the chassis with a removable shorting strap located at the rear of the instrument.

11.2 The return lead of the accelerometer input shall be isolated from the chassis to minimize ground loops, and to permit the injection of an external oscillator signal into the return lead according to Paragraph 6.0.

12.0 Power Requirements

The instrument shall operate from a 105-125 volt, 60 cps power line. The maximum line current for 6 channels shall be 2.5 amps.

13.0 Physical

The instrument shall be arranged for 19" rack mounting with a frame and power supply prewired to accept six modular amplifiers. All cable connections shall be at the rear. Modules shall be removable from the front.

13.1 Dimensions

The dimensions shall be no greater than 19" wide x 8 3/4" high x 21" deep. Handles shall be provided on the front panel.

13.2 Connectors

13.2.1 Transducer Input - Shall be BNC type that can be converted for use with low noise Microdot type cable with a Microdot 33-101 adapter. Adapter shall be furnished by buyer.

13.2.2 Outputs - Shall be BNC type for each output. A maximum of 5 each BNC connectors per channel can be supplied.

13.2.3 Oscillator Input - Shall be BNC type with only one connector required for all 6 channels.

13.3 Channel Identification

A front panel thumb screw that is engraved with the channel number shall be provided for sequentially numbering each channel supplied on this specification.

13.4 Finish

Panels shall be painted a light metallic grey.

13.5 Panel Marking

Lettering on front panel shall be silk screened or engraved in black letters except markings relative to sensitivity settings shall be red.

13.6 Chassis Marking

Top of chassis components and rear connectors shall be clearly labeled with silk screen markings.

13.7 Cooling

Sufficient cooling shall be provided by integral fans such that five of the six channel frames can be mounted vertically in a 19" rack console without spacing between units and operate continuously as long as the ambient temperature in the console is maintained at 110°F or less.

CALIBRATION AND CHECKOUT PROCEDURE1.0 Checkout Instruments Required

- 1.1 Audio Oscillator
- 1.2 AC Electronic Voltmeter
- 1.3 Oscilloscope

2.0 Instrument Connections

All input and output connectors are located at the rear of the Model CV608RMG-6.

- 2.1 OSCILLATOR INPUT - The audio oscillator must be connected to the ACCEL IN BNC connector through a series 1000 pf capacitor. Location of this calibration capacitor in a shielded enclosure will prevent unwanted pickup. This shielded enclosure should provide continuity of the input cable shields, but should not inadvertently, make contact with the instrument chassis or ground potential at a second location so as to create a ground loop.
- 2.2 OUTPUT SIGNALS - Three types of output signals are available for each channel of the 608 instrument at separate BNC output connector.
 - 2.2.1 Tape Out - This is a voltage output which is suitable for tape recorders, meters, oscilloscopes or other low current readout instruments.
 - 2.2.2 Galvo Out - This is a high current capacity output which is suitable for driving galvanometer type oscillograph recorders.
 - 2.2.3 10 mv/g Out - This signal is not affected by the FULL SCALE RANGE (g) Switch, and is suitable for use with the BK Automatic Vibration Exciter Control, or high sensitivity X-Y Type Recorders. Connect the 10 mv/g output of the channel to be checked to the electronic voltmeter and the oscilloscope.

3.0 Operating Instructions

Before checking the performance of the 608 instrument, sections 1.0 and 2.0 of the Instruction Manual should have been thoroughly read, and the block diagram in Figure 1 should have been studied.

4.0 Initial Control Settings

- 4.1 CHARGE, VOLTAGE MODE Switch - CHARGE
- 4.2 FULL SCALE RANGE (g) Switch - 10g

- 4.3 Full Scale Multiplier Switch (X1, X10)-X1
- 4.4 Sensitivity Range Switch - (1-10)
- 4.5 Sensitivity Dial - 10.00
- 4.6 CAL/NORM/TEST Switch - NORM
- 4.7 TAPE GAIN and GALV GAIN Dials - 6.0 (not essential)
- 4.8 Oscillator
 - 4.8.1 Frequency - 1 kc
 - 4.8.2 Amplitude - 70.7 mv rms (100 mv peak)
- 4.9 Connect the 608 to the 115V, 60 cycle line. Allow 15 minutes for warm-up and temperature stabilization before making any calibration adjustments. Check that the "charge" mode indicator lights are energized for all the channels.

5.0 Calibration and Performance Checks

- 5.1 Normalization of 10 mv/g Output - with the input signals, output connections, and control settings described above, set the ACCEL ADJUST potentiometer to provide 70.7 mv rms (100 mv peak). The potentiometer is located on top of the module chassis toward the front. This pot is accessible through a hole directly above the pot in the top of the 608 frame.
- 5.2 Normalization of Meter Reading - Set the METER ADJUST potentiometer to provide a 10g reading. The potentiometer is located on top of the module chassis toward the middle. The pot is accessible through a hole directly above the pot in the top of the 608 frame. This gain adjustment should be made with all the modules in their proper channel locations.

- 5.3 Full Scale Multiplier Switch - Move this switch to the X10 position. Increase the oscillator voltage to .707 volts rms. The 608 meter should read 10 g. The 10 mv/g output should be 70.7 mv rms.
- 5.4 Sensitivity Range Switch - Rotate this switch to the (10-100) position. Return the Full Scale Multiplier Switch to the X1 position. The 608 Meter should read 10 g.
- 5.5 Sensitivity Dial - Decrease the oscillator voltage to approximately 70.7 mv rms. Rotate the Sensitivity Range Switch to the (1-10) position. Set the Sensitivity Dial to 10.50 (upper end of the dial). Adjust the oscillator voltage until the 608 meter reads 10 g. Rotate the Sensitivity Range Switch to the (10-100) position. Set the Sensitivity Dial to a reading of 1.05 (lower end of the dial), and then trim the setting until the 608 meter reads 10 g again. The Sensitivity Dial should read between 1.06 and 1.04, which is within 1% of the desired 1.05 reading.
- 5.5.1 If the dial setting comes out to be less than 1.04, ~~the~~ knob must be moved CW relative to the potentiometer shaft. To move the knob CW with respect to the pot shaft, first rotate the knob full CW. The dial should read $11.00 \pm .05$. Loosen the knob set screw, being careful not to allow the pot shaft to back away from its mechanical stop. When the set screw has been loosened sufficient to rotate the knob further CW, turn the knob the required number, or fraction, of divisions and lock in place. Return the dial to the 1.05 position and trim for a 10 g reading. If the above steps have been performed properly, the dial setting should be between 1.06 and 1.04.
- 5.5.2 If the dial setting comes out to be greater than 1.06 the knob must be moved CCW relative to the potentiometer shaft. Rotate the knob full CCW against the stop and then proceed as in 5.5.1 except for taking the reversal of rotations into account.
- 5.5.3 If the dial offset is greater than 11.05 when the knob is rotated full CW, the gain of Nuvistor V5 or V6 is probably low. Replace the 7587 Nuvistors before resetting the dial. If the dial offset is changed appreciably from the setting involved when procedure 5.1 was performed, then 5.1 should be repeated.
- 5.6 Distortion at 100 g - With the Sensitivity Dial set at 10.0, the Sensitivity Range Switch in the (1-10) position, and the FULL SCALE RANGE Switch at 100 g, increase the oscillator voltage to .707 volts rms. The 10 mv/g output waveform displayed on the scope should not be distorting at the peaks.

5.7 METER FULL SCALE RANGE (g) Switch

- 5.7.1 With the conditions of 5.6, the 608 meter should read 10.0 ± 0.1 on the upper meter scale.
- 5.7.2 Reduce the oscillator voltage 10 db to .224 volts rms, and rotate the meter range switch to 30g. The 608 meter should read 10.0 ± 0.1 on the upper scale. (This is 31.6g on the lower scale.)
- 5.7.3 Reduce the oscillator voltage 10 db to 70.7 mv rms, and rotate the meter range switch to 10g. The 608 meter should read 10.0 ± 0.1 on the upper scale.
- 5.7.4 Reduce the oscillator voltage 10 db to 22.4 mv rms, and rotate the meter range switch to 3g. The 608 meter should read 10.0 ± 0.1 on the upper scale. (This is 3.16 g on the lower scale.)
- 5.7.5 Reduce the oscillator voltage 10 db to 7.07 mv rms, and rotate the meter range switch to 1g. The 608 meter should read 10.0 ± 0.1 on the upper scale.

5.8 Galvo Output Signal Clipping at Maximum Drive

- 5.8.1 With the Sensitivity Dial at 10.0, the Sensitivity Range Switch in the (1-10) position, and the FULL SCALE RANGE (g) Switch at 10g, set the oscillator voltage to 70.7 mv rms. Connect the galvo output signal to the electronic voltmeter and the oscilloscope. These instruments should be set on a range suitable for monitoring 7.07 volts rms. Rotate the GALV GAIN Dial CW until the output voltage is 7.07 volts rms. The output wave form should not be clipping on the peaks.
- 5.8.2 Rotate the GALV GAIN Dial CCW until the output voltage is 5.0 volts rms. Connect a 70 ohm resistor across the output. The output waveform should not be clipping on the peaks.

5.9 Tape Output Signal Clipping at Maximum Drive - With the conditions of 5.8.1, connect the tape output signal to the electronic voltmeter and the oscilloscope. These instruments should be set on a range suitable for monitoring 2.0 volts rms. Rotate the TAPE GAIN Dial full CW. The output voltage should be greater than 1.76 volts rms (2.5 volts peak) and generally less than 2.2 volts rms. The output waveform should not be clipping on the peaks.

5.10 Frequency Response

5.10.1 Meter Readout

With the conditions of 5.8.1, increase the oscillator frequency to 10 kc and set the input voltage to 70.7 mv rms.

Section 5

The 608 meter should read $10.0 \pm 0.2g$. Change the oscillator frequency to 5 cps and set the input voltage to 70.7 mv rms. It may be necessary to use the scope in the dc mode if the electronic voltmeter is not calibrated down to 5 cps. The average reading of the 608 meter should be $10.0 \pm .02g$.

5.10.2 10 mv/g Output

Under the same conditions as 5.10.1, the 10 mv/g output should be 70.7 mv rms $\pm 2\%$ at 10 kc and 5 cps.

5.10.3 Tape Output

Under the same conditions as 5.10.1, and with the TAPE GAIN set at maximum output (full CW) the tape output should be flat within $\pm 2\%$ at 10 kc and 5 cps. (If desired, the tape output high frequency cutoff can be varied by adjusting the 100 K trim pot located inside the module side cover and mounted on the shield partition nearest the front. An increase in the pot resistance decreases the cutoff frequency. It is recommended that the pot resistance not be set below approximately 20 K.)

5.10.4 Galvo Output

Under the same conditions as 5.10.1, and with the GALV GAIN set for 5 volts rms, the galvo output should be flat within $\pm 2\%$ at 2 kc and 5 cps, and within $\pm 5\%$ at 5 kc.

5.11 Noise Level

- 5.11.1 Connect the electronic voltmeter to the tape out and normalize for 1 volt rms at full scale. Remove the oscillator and 1000 pf capacitor from the ACCEL IN BNC connector and attach a nominal 10 pcmb/g accelerometer and 100 ft. or less of low noise coaxial cable. Set the Sensitivity Range Switch to the (10-100) position, the Sensitivity Dial to 1.0, and the Full Scale Multiplier Switch to X1, and rotate the FULL SCALE RANGE (g) Switch to the 1 g position. The average noise reading should be less than 20 mv rms.

Section 5

Note: For valid noise readings, the attached accelerometer should not be the case sensitive type. The accelerometer should be absolutely motionless, and 60 cycle instrument ground loops should be eliminated. It may be necessary to reverse line plug polarities to achieve a minimum ground loop setup.

- 5.11.2 Rotate the Sensitivity Dial to 10.0. Set the Sensitivity Range Switch to the (1-10) position. The average noise reading should be approximately 10 mv rms.

5.12 CAL Mode of Operation

- 5.12.1 Local - With the controls under the same conditions as 5.11, move the CAL/NORM/TEST switch handle to the up or CAL position. The output signal levels should be at 100% of full scale value within $\pm 1\%$, independent of the sensitivity range settings. The switch should return to the center or NORM position when the handle is released.
- 5.12.2 Remote - Apply -28VDC to pin A of the rear mounted remote command connector MS 3102A-10SL-3P. Pin B is the chassis or ground connection. The output signal levels should be at 100% of full scale value within $\pm 1\%$, independent of the sensitivity and range settings. The command signal current should be approximately 30 ma per channel, or 180 ma for 6 channels. Remove the remote CAL command signal.

5.13 TEST Mode of Operation

- 5.13.1 Local - Attach a combined cable plus accelerometer capacitance of 3800 pf to the ACCEL IN connector. Move the CAL/NORM/TEST switch handle to the down or TEST position. The output signal levels should be at approximately 50% of full scale value. Source capacitance less than 3800 pf will produce a smaller output signal level and a source capacitance greater than 3800 pf will produce a larger output signal level.
- 5.13.2 Remote - Apply -28VDC to both pins A and C of the rear mounted remote command connector. Pin B is the chassis or ground connection. The output

should be at approximately 50% of full scale value when the source capacitance is 3800 pf. The command signal current should be approximately 60 ma per channel, or 360 ma for 6 channels. Remove the remote TEST command signal.

- 5.14 Voltage Mode - Disconnect the 608 from the 115 vac line. Remove each module from the frame assembly and set the CHARGE, VOLTAGE Mode Selector Slide Switch in the up or VOLTAGE position. Return each module to its same channel location. Set the front panel controls to the initial settings described in Paragraph 4.0. Apply ac power and check that the "voltage" mode indicator lights are energized. Connect the oscillator to the ACCEL IN BNC connector for the channel to be checked and readjust to 70.7 mv rms. Allow 15 minutes for warmup and stabilization. The 10 mv/g output and the meter reading should remain normalized within $\pm 1\%$ of 10g.

When the oscillator is moved to the next channel, allow several minutes for the input cathode follower gain to stabilize.

After completion of the "voltage" mode check, be sure to disconnect the oscillator from the accelerometer input connector, particularly if the module is to be switched to the "charge" mode of operation.

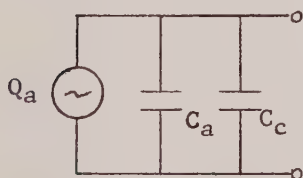
APPENDIXCHARGE AMPLIFIER ANALYSIS

The primary function of a so called charge amplifier is to provide a voltage output proportional to a charge generated at the input. The operation of such a device is based on a high gain amplifier with capacitive feedback from output to input. Analysis of such a circuit may be made in terms of either charge units or voltage units. From a voltage viewpoint the circuit amplifies a voltage with the feedback arranged to vary the voltage gain proportional to the shunt capacitance at the input. Since charge generating transducers produce a voltage inversely proportional to shunt capacitance the combination produces an output voltage proportional to charge.

The following simplified analysis utilizes the conventional voltage generating equivalent circuit for an accelerometer and explains the operation of the amplifier on a conventional voltage basis.

Voltage Amplifier

The actual circuit of an accelerometer is a charge generator with shunt capacitance equal to the capacitance of the accelerometer plus any cable capacitance.



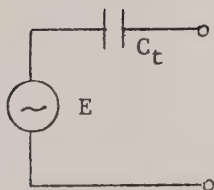
Q_a = Charge Generator

C_a = Accelerometer Capacitance

C_c = Cable Capacitance

Note: Shunt resistance has been neglected

This circuit can be represented by its equivalent in the form of a voltage generator.

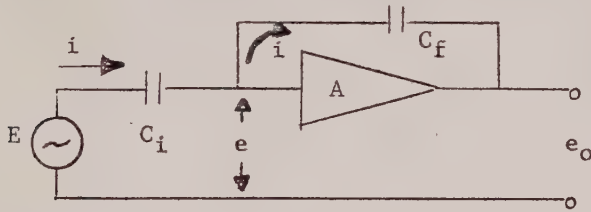


$$E = Q_a / C_t$$

$$C_t = C_a + C_c$$

Section 6

Combining this circuit with the amplifier yields



$$Z_i = \frac{1}{sC_i}$$

$$Z_f = \frac{1}{sC_f}$$

Let Z_a the amplifier input impedance be very much greater than Z_f and therefore negligible.

$$\text{Then } E - i(Z_i + Z_f) = e_o$$

$$E - iZ_i - e = 0$$

$$-i = \frac{e - E}{Z_i}$$

$$\text{but } e_o = eA$$

$$-i = \frac{e_o - AE}{AZ_i}$$

but

$$E + \frac{e_o - AE}{A} + \frac{e_o Z_f}{AZ_i} - \frac{E Z_f}{Z_i} = e_o$$

$$\left\{ e_o \frac{Z_i + Z_f}{AZ_i} - 1 \right\} = E \frac{Z_f}{Z_i}$$

$$\frac{e_o}{E} = \left\{ \frac{A Z_f}{Z_f + Z_i(1-A)} \right\}$$

$$\frac{e_o}{E} = \frac{Z_f}{\frac{Z_i + Z_f - Z_i}{A}}$$

$$\text{If } \frac{Z_i + Z_f}{A} \ll Z_i$$

$$\frac{e_o}{E} \approx -\frac{Z_f}{Z_i} \approx -\frac{C_i}{C_f}$$

$$\text{but } E = \frac{Q}{C_i}$$

$$\therefore \frac{e_o}{Q} \approx -\frac{1}{C_f}$$

Thus the ratio of output voltage to charge is independent of C_i .

In order to determine the validity of the approximation

$$\frac{Z_i + Z_f}{A} \ll Z_i$$

A

Check actual circuit values that would yield a 1% error

$$\text{Then } \frac{Z_i + Z_f}{A} = .01 Z_i$$

$$Z_i \left(\frac{1}{A} - .01 \right) = \frac{-Z_f}{A}$$

$$\frac{Z_f}{Z_i} = .01A - 1$$

$$\text{for } A = 5000 \text{ and } C_f = 10^{-9}$$

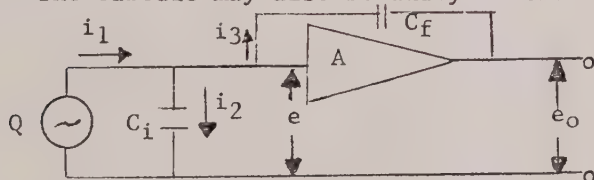
$$\frac{C_i}{C_f} = 50 - 1 = 49$$

$$C_i = .049 \text{ mfd or approximately 1500 ft. of coax cable}$$

Thus C_i the source capacitance may vary from very small values up to 49,000 pf with only a 1% change in output.

Charge Amplifier

The circuit may also be analyzed from a charge point of view.



$$i_1 = i_2 + i_3$$

$$SQ = C_i S e + C_f S (e - e_o)$$

$$\text{but } e_o = A e$$

$$\frac{e_o}{Q} = \frac{A}{C_i + C_f (1-A)}$$

$$= \frac{1}{-C_f + \frac{C_i + C_f}{A}}$$

$$\text{for } C_f \gg \frac{C_i + C_f}{A}$$

$$\frac{e_o}{Q} \approx -\frac{1}{C_f}$$

PERFORMANCE CONSIDERATIONS FOR AUTOMATIC-RANGING ACCELERATION-MONITORING EQUIPMENT

By **THERON USHER, JR.**

Unholtz-Dickie Corporation

As reprinted from

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APRIL 1965

manufacturers of complete vibration test systems and instruments

UNHOLTZ-DICKIE CORPORATION

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PERFORMANCE CONSIDERATIONS FOR AUTOMATIC-RANGING ACCELERATION-MONITORING EQUIPMENT

By THERON USHER, JR.

Unholtz-Dickie Corporation

INTRODUCTION

As a part of the sinusoidal vibration testing of reasonably large test specimens, it is becoming common practice to monitor the acceleration at many points on the specimen simultaneously. The output signals from the accelerometers are generally fed to a corresponding number of amplifiers with indicating meters or calibrated outputs for driving recorders, or both. Several manufacturers supply signal-conditioning amplifiers of this type.

Generally, the sinusoidal vibration testing procedure consists of sweeping the frequency at a prescribed rate and automatically controlling the amplitude of the acceleration at a mounting point of the test specimen in a prescribed fashion. The acceleration magnitudes at the other monitored points on the specimen may vary widely as functions of frequency due to resonances in the specimen. In such a situation, the operator finds it difficult, if

not impossible, to keep all the meters and recorder channels on scale by manual range-switching. Automatic range-selecting circuits within each signal conditioning amplifier are almost a necessity.

It is the purpose of this paper to describe the operation of a simple automatic range-selecting circuit and to show how the operating characteristics affect the performance under typical vibration testing conditions.

OPERATION OF AUTOMATIC RANGE SELECTOR

A simple two-range automatic range-selecting amplifier is shown in Figure 1 in block diagram form. A sinusoidal signal from an accelerometer is applied to the gain-calibrated amplifier. The gain-calibrated amplifier feeds the signal to the two-step attenuator and also to a full-wave rectifier. The dc component at the output of the full-wave rectifier is recovered by a low-pass filter and is applied to the trigger cir-

cuit. When the amplitude of the input sinusoidal exceeds the full-scale value for the meter circuit or the recorder, then the voltage applied to the trigger circuit also exceeds a critical value. This causes the trigger circuit to apply voltage to the relay. The relay arm then switches to the lower position on the attenuator, thus bringing the meter or recorder indication downscale and allowing a larger full-scale indication.

The operation of the automatic switching circuit is always accompanied by a certain amount of hysteresis which is also necessary for low frequency operation. That is, the voltage at which the trigger circuit applies power to the relay is higher than the voltage at which the trigger circuit removes excitation. The latter operation results in the relay arm moving back to the top of the attenuator and providing a lower full-scale value for the instrument. The hysteresis is shown in Figure 2 which shows the output, $s(t)$, of the trigger circuit as a function of the input, $y(t)$.

HYSTERESIS AND MINIMUM FREQUENCY OF OPERATION

The hysteresis of the trigger circuit is easily adjustable by varying the circuit parameters. It is desirable to have H as large as possible to have reliable low frequency operation but it cannot be too large for good utilization of the meter scale.

As the frequency of operation decreases, the low-pass filter not only passes the dc component of the output of the full-wave rectifier but also some of the harmonic components, notably the second harmonic of the input frequency. This ripple, added to the dc component, can cause the relay to switch ranges back and forth at a frequency equal to the second harmonic of the input. This is possible because the trigger circuit and the relay are

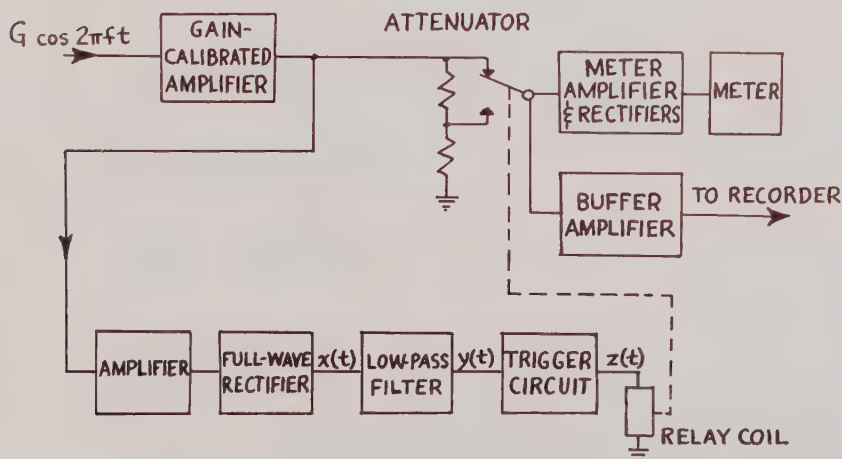


FIGURE 1

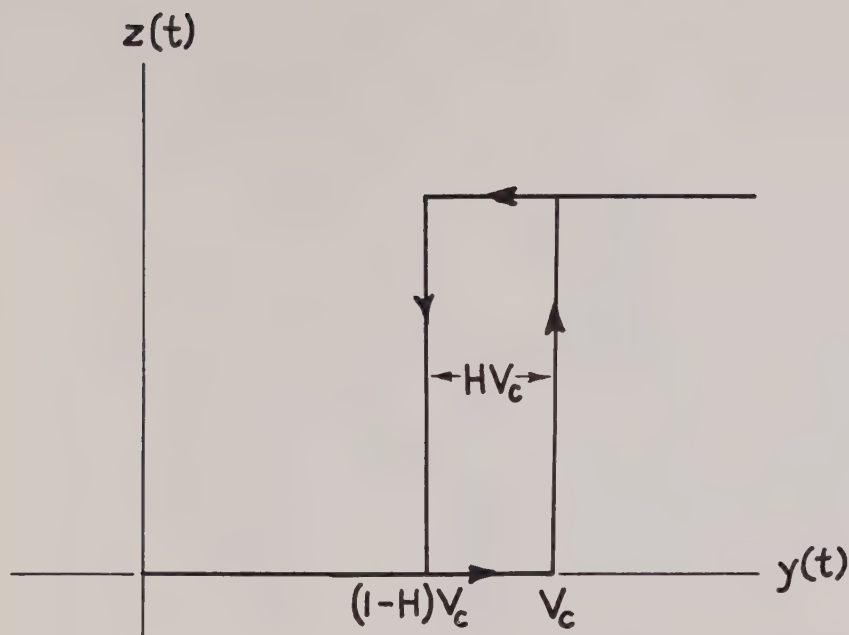


FIGURE 2

fairly fast acting.

The conditions for incipient chattering action are satisfied when the dc component of $y(t)$ is half way between the two critical switching points in Figure 2 and the peak-to-peak value of the second harmonic ripple is equal to the amount of hysteresis. If it is assumed that the low-pass filter is a simple R-C network, and since the peak value of the second harmonic component of a full-wave rectified sinusoidal is two-thirds of the dc component, the mathematical expression that satisfies the above statement is:

$$\frac{2}{3} \left(1 - \frac{H}{2}\right) [1 + (2\pi 2fT)^2]^{-1/2} = \frac{H}{2} \quad (1)$$

In Eq (1), T is the time constant of the R-C filter, and f is the minimum frequency of operation without the occurrence of chattering. Solving for the frequency, one easily obtains

$$f = \frac{(1 - H - \frac{5}{16}H^2)^{1/2}}{3\pi HT} \approx \frac{1}{3\pi HT} \quad (2)$$

Equation (2) shows that another way to lower the frequency at which chattering occurs is to increase the filter time constant. Increasing the filter time constant greatly causes the dynamic response of the instrument to be limited, as explained in the following section.

DYNAMIC RESPONSE TO CHANGING INPUTS

In a great number of situations, the magnitude, G , of the input is not a

constant but varies with time. As mentioned previously, this occurs during vibration tests when the frequency is sweeping, due to the changing frequency response of the specimen. The time rate of change of G is most severe near the resonance peaks and notches of the system response function.

Statically, the output, y , of the low-pass filter is proportional to the input magnitude, G . However, if the input magnitude, G , changes with time, the input of the low pass filter lags behind the static value because the response time is limited by the filter time constant. This lag is always present regardless of the design of the low-pass filter, because low-pass filtering is always accompanied by limited speed of response in the time-domain. In this discussion, the ripple is considered negligible.

If the rate of change of G is particularly large, or if the time response of the filter is particularly slow, or both, the switching level for $y(t)$ may not be reached until G is considerably above the full-scale value of the instrument. This may cause the recorder to go offscale momentarily unless the maximum deflection of the recorder considerably exceeds the full scale output of the instrument. It is the purpose of this section to investigate the relationships that allow one to keep the dynamic error in switching level below a specified amount. Note that no data is lost but that the automatic switching operation simply is slightly

later in time than it should be for ideal operation.

If the frequency of the excitation to the specimen is being swept through values causing a resonance peak, the value of the input magnitude G is

$$G(t) = K \left[1 + \left(2 \frac{f - f_0}{B} \right)^2 \right]^{-1/2} \quad (3)$$

In Eq. (3), f_0 is the resonance frequency, B is the bandwidth between half-power points, and f is the frequency, which is changing with time.

The difference between the actual output of the low pass filter and the value that would exist if the input magnitude were constant with time will be defined as the error and is approximated closely²

$$e(t) = y(t) - y_{static} \approx -T \frac{dx}{dt} \quad (4)$$

The error relative to the static output or "relative error" is the important quantity since this defines the relative amount that the input must succeed the full scale value before the range-switching actually takes place in the dynamic situation. The relative error is

$$E_r = \frac{e(t)}{y_{static}} = \frac{\left(\frac{2T}{B} \right) \left(\frac{2f - f_0}{B} \right) \frac{df}{dt}}{1 + \left(\frac{2f - f_0}{B} \right)^2} \quad (5)$$

The maximum value of E_r occurs when the frequency is equal to the half-power frequencies or when

$$|2(f - f_0) / B| = 1$$

The limiting value for the frequency sweep rate df/dt thus becomes

$$\frac{df}{dt} \leq |E_r| \frac{B}{T} \quad (6)$$

With a fixed value of $|E_r|$, the frequency sweep rate must be slow if the filter time constant T is large. Thus a compromise is clearly indicated for obtaining the objectives of high sweep rates and low values for the frequency at which chattering of the range-switching relay is evident. Typical parameters which allow satisfactory operation for vibration testing applications are given in the following section.

APPLICATION TO TYPICAL VIBRATION TESTING REQUIREMENTS

A satisfactory hysteresis value to select for the difference between the up-

ABOUT THE AUTHOR

Theron Usher, Jr. received a D. Eng. degree in Electrical Engineering from Yale University in 1957. From 1955 through 1964 he was on the faculty at Yale in the Department of Electrical Engineering. During this time, he was also a consultant to the vibration testing industry and contributed to the design of random vibration testing systems. In July, 1964 he joined the Unholtz-Dickie Corporation as Director of Research and Development and at present is also an independent consultant for the Electric Boat Company. He is author of a number of publications in the areas of vibration testing, audio amplifier theory, and underwater acoustic signal processing.

He is a member of the Institute of Electrical and Electronics Engineers, Acoustical Society of America, and Sigma Xi.



ranging point on Figure 2 and the down-ranging point is 10%. For a filter time constant of 50×10^{-3} seconds we obtain a minimum frequency of operation of

$$f = \frac{1}{(3\pi)(0.1)(50 \times 10^{-3})} = 21 \text{ cps}$$

Before the effect on dynamic switching error is evaluated, it is desirable to develop an expression for df/dt for a frequently used commercial instrument. The Bruel and Kjaer Automatic Vibration Exciter Control has a logarithmic frequency sweep described by

$$\Theta = \frac{220}{6.9} \ln \left(\frac{f}{5} \right) \quad (7)$$

where Θ is in degrees of shaft rotation for the main tuning dial. The sweep speeds are given in terms of $d\Theta/dt$ in degrees/minute. From Eq. (7) the sweep speed $d\Theta/dt$ is

$$\frac{d\Theta}{dt} = 1910 \frac{1}{f} \frac{df}{dt} \quad (8)$$

Combining Eq. (8) with Eq. (6), we obtain a limiting value for the sweep speed.

$$\frac{d\Theta}{dt} \leq 1910 |E_r| \frac{1}{QT} \quad (9)$$

In Eq. (9), $f/B \simeq Q$ because the maximum error occurs at a frequency quite near the resonance frequency.

A satisfactory value for maximum dynamic switching-level error is 10%. A value of $Q=50$ is a reasonable number to assume for the maximum Q encountered in a vibration test. For the previously selected value of $T=50 \times 10^{-3}$ seconds, the maximum sweep rate is

$$\begin{aligned} \frac{d\Theta}{dt} &\leq \frac{(1910)(0.1)}{(50)(50 \times 10^{-3})} \\ &= 76.5 \text{ degrees/min.} \end{aligned}$$

This corresponds to a running time of 5 minutes for a test with the frequency sweeping from 5 to 2000 cps

and back again. This sweep rate is several times faster than those usually used in military specifications (See MIL-E-5272C[ASG], MIL-STD-202C, MIL-STD-810).

A time constant of 50×10^{-3} seconds would seem to be not quite adequate from the standpoint of chattering occurring, for tests going as low as 5 cps. However, it must be remembered that most tests at low frequencies require constant displacement, and that the acceleration at 5 cps is very likely at the low end of the lowest scale of an automatic range-selecting acceleration monitor. This is done on purpose to give as large a dynamic range as possible for the instrumentation. The first range-switching point very likely occurs at a frequency higher than 21 cps.

In any event, the time constant can be increased to 200×10^{-3} seconds to allow chatter-free operation down to 5 cps, and in practically all test situations, the sweep speed required will not be more than $76.5/4$ or 19 degrees/min. It also must be remembered that the dynamic error in switching level equals the specified value of 10% only when range switching occurs at the half-power frequency of the resonance. At all other frequencies and for resonances having Q less than 50, the error is much less than 10%. Automatic range-switching acceleration monitors usually offer more than one filter time constant to allow the operator to select one of his choice.

The Bruel and Kjaer Automatic Vibration Exciter Control has sweep speeds available to a maximum of 335 degrees/minute. However, speeds approaching the maximum are rarely used, since most vibration testing requires automatic control of vibration level to roughly 10% accuracy. To obtain this accuracy with highly resonant test specimens, the sweep speeds must

be much lower than 335 degrees/minute to allow the automatic gain control circuit to function properly. Features of this problem are quite similar to the dynamic range-switching problem investigated above.

Also of interest to the vibration test engineer is the amount of data actually lost while the instrument is switching from one range to the other. This can be evaluated from Eq. (9) if one interprets T as the relay switching time, that is, the time that the relay arm is between contacts in Figure 1. For $Q=50$, a relay switching time of 3×10^{-3} seconds, and $d\Theta/dt = 76.5$ degrees/min. the amplitude changes at most by the amount given in the following relation during the time the relay is not making contact.

$$\begin{aligned} \frac{\Delta G}{G} &= \frac{1}{1910} T Q \frac{d\Theta}{dt} \\ &= \frac{(3 \times 10^{-3})(50)(76.5)}{1910} = 6 \times 10^{-3} \\ &= (0.6\%) \quad (10) \end{aligned}$$

The amount given in Eq. (10) is a worst-case situation, occurring if switching takes place at the worst time, for a resonance having maximum Q , and at a sweep rate higher than that used for practically all tests. The amplitude change of 0.6% shows that a negligible amount of data is actually lost or not available to be recorded.

SUMMARY

The discussion in the foregoing section shows that satisfactory operation may be obtained from the standpoints of minimum frequency of operation and dynamic switching-level error by using a relatively unsophisticated approach to the problem of automatic range selection. Simple circuitry is desirable from the economic standpoint since many channels of automatic range-selecting monitors are often used.

A commercially available instrument should contain more than two automatically-selectable ranges. The difference between a multi-range instrument and the one diagrammed in Figure 1, is that the multi-range instrument contains more than one switching circuit and a more complicated relay switching network. Usually, means are also included for providing an output code for determining which range of the instrument is actually in operation at any particular time.

REFERENCES

1. Reference Data for Radio Engineers, 4th Ed., p. 1022, International Telephone and Telegraph Corp., 1949.
2. Bower and Schultheiss, *Intro. to the Design of Servomechanisms*, pp. 248-257, John Wiley & Sons, 1958.

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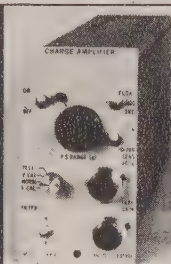
vibration generation systems and measurement instruments

Signal conditioning amplifiers for shock and vibration monitoring

This popular series of signal conditioning amplifiers features individual double shielded power supplies, a totally-enclosed-vinyl-clad case, portability of separate units, ultra low noise levels, frequency response to 100 kHz, and switchable low pass filters with an 18 dB/octave attenuation rate. They can be operated in the integral charge mode with direct connection to the piezoelectric transducer, or switched to the remote

preamp mode for operation with either the two-wire charge type remote preamp or the two-wire voltage type remote preamp. Full scale ranges of .1 g to 10 Kg with accelerometer sensitivities from 1 pC/g to 100 pC/g are standard. Also offered is Option III full scale ranging to provide an extra gain of 10 for very low level measurements. Panel height is only 5 1/4 inches when standard edgewise meters are selected.

D11V SERIES



Model D11V

Tape output only

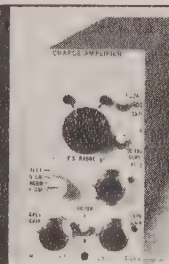
\$525.00



Model D11MV

Tape and meter

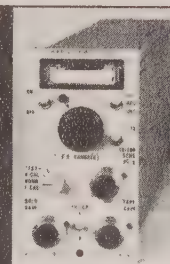
\$575.00



Model D11GV

Tape and galvo

\$590.00



Model D11MGV

Tape, galvo, meter

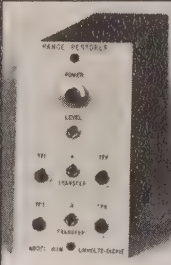
\$640.00

Basic D11V series permits operation with grounded transducers while eliminating usual ground loop problems. Differential circuitry provides rejection of common-mode signals by a factor of 1000. The two-wire remote preamps shown below can be used with any of the D11V series instruments.

OPTIONAL FEATURES

L	Log dc output with 60 dB dynamic range (requires meter feature)	\$175.00
S	Normalized 10 mV/g servo output for full scale ranges up to 300 g	\$50.00
O	1 kHz fixed amplitude, sine wave, internal calibration oscillator	\$50.00
-8	Large meter with 2 1/2 inch scale length and 8 3/4 inch panel height	\$20.00
-2	Extended low frequency response flat within $\pm 5\%$ down to 0.5 Hz	\$25.00

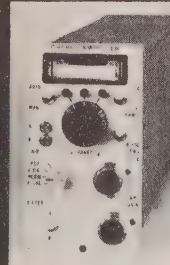
AUTORANGER SERIES



Model 811M

Range restorer

\$1200.00



Model 11MAV

Tape and meter

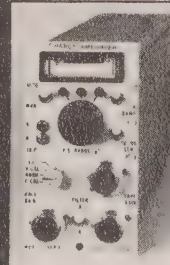
\$745.00



Model 11GAV

Tape and galvo

\$760.00



Model 11MGAV

Tape, galvo, meter

\$810.00

AUTORANGER series selects best of 3 adjacent full scale ranges. Pilot light and dc code signals indicate range selected. Range sequences of 1, 3, 10, ..., or 10 dB steps, or 1, 10, 100, 1K are offered. Companion RANGE-RESTORER converts tape recorded data to original dynamic range. The two-wire remote preamps shown below can be used with any of the AUTORANGER instruments.

OPTIONAL FEATURES

S	Normalized 10 mV/g servo output for full scale ranges up to 1 Kg	\$50.00
O	1 kHz fixed amplitude, sine wave, internal calibration oscillator	\$50.00
F	Linear DC output for amplifiers supplied with meter feature	\$25.00
-8	Large meter with 2 1/2 inch scale length and 8 3/4 inch panel height	\$20.00

SHOCK SERIES



Model 11TPM

Transient peak meter

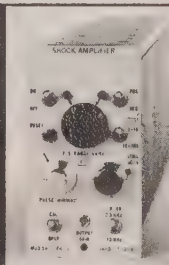
\$350.00



Model SA11TPM

Shock amplifier with tape and transient meter

\$875.00



Model SA11G

Shock amplifier with adjustable galvo output

\$615.00



Model SA11MG

Shock amplifier with galvo, and standard meter

\$665.00

Shock amplifiers have selectable low and high frequency time constants for pulse durations from 100 microsec to 100 millise. Reset feature and direct coupling provide rapid stabilization. Series shown at left can be intermixed with other series 11 instruments. Series described below are housed in a single portable carrying case that can be rack mounted as one, two or three units.

PORTABLE SHOCK INSTRUMENTS

Model SA11GQ-3	Portable shock amplifier with galvo and internal oscillator
Model 11TPM-3	Portable transient peak meter for pulse measurements
Model 11RA-3	Rack adapter for 1 to 3 of the portable units above.

OPTIONAL FEATURES

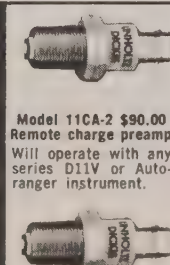
1 kHz Osc.	\$50.00	10 mV/g Servo	\$50.00
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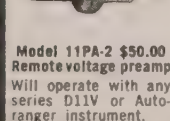
Model V11MS

Tape, meter, servo

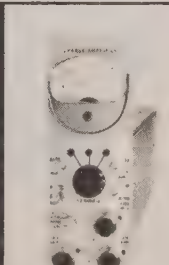
Economy model operates exclusively with two-wire remote charge or voltage preamp shown at right. Galvo option \$65.00
OSC option \$50.00



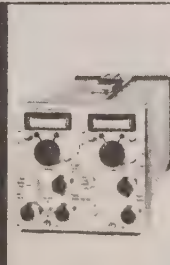
Model 11CA-2 \$90.00
Remote charge preamp
Will operate with any series D11V or Autoranger instrument.



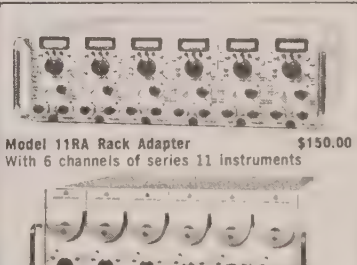
Model 11PA-2 \$50.00
Remote voltage preamp
Will operate with any series D11V or Autoranger instrument.



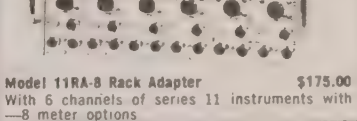
Series 11 Instrument
with -8 meter option.



Model 11P-2 \$70.00
Dual channel
Portable adapter
With 2 channels of series 11 instruments

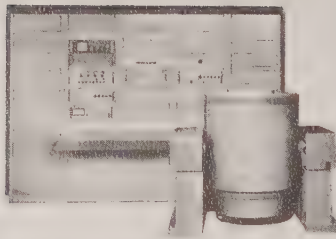


Model 11RA Rack Adapter \$150.00
With 6 channels of series 11 instruments

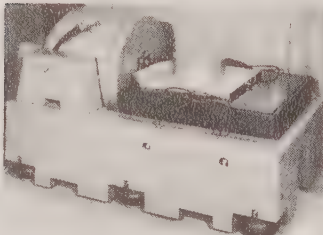


Model 11RA-B Rack Adapter \$175.00
With 6 channels of series 11 instruments with -8 meter options

Complete vibration test systems



15000 lb system with solid state amplifier



Shaker and slip table on seismic base

SYSTEM	SYSTEM	SHAKER TABLE					SYSTEM COOLING			
Model Number	Force Sine lbs.-pk	Stroke inches pk-pk	Bolt Circle Max. Dia.	Suspension Stiffness lbs/in.	Weight lbs.	Frequency Range - Hz	Amplifier	SHAKER		
								Moving Element	Field	
TA 100-4	150	4	—	Nil	3	dc-1000	Air	Air	Air	
TA 250-6	1000	6	—	Nil	11	dc-1000	Air	Air	Air	
TA 50-20	200	1	3.5	80	2	dc-3000	Air	Air	Air	
72-7	200	1	4.5	225	4	5-10000	Air	Air	Air	
TA 250-100	350	1	4.5	225	4	dc-6000	Air	Air	Water	
76-7	350	1	4.5	225	4	5-10000	Air	Air	Water	
340-7	350	0.5	2.25	50	2.5	5-10000	Air	Air	Water	
279	450	1	4.5	225	5.3	5-5000	Air	Air	Water	
TA 161	1000	1	5.75	250	14	dc-2000	Air	Air	Air	
262-8	1200	1	8	400	20	5-3000	Air	Air	Air	
464-8	1700	1	8	400	20	5-3000	Air	Air	Air	
454	1750	1.25	8	600	20	5-3000	Air	Air	Air	
484H	2000	1.25	8	600	20	5-3000	Air	Air	Air	
8208 AAA	2600	1.25	8	600	27	5-5000	Air	Air	Air	
8208 AMA	3000	1.25	8	600	20	5-3000	Air	Air	Air	
8208 PH	3000	1.25	5.75	300	14	5-2000	Air	Air	Air	
691M-50	5000	1.25	12	1200	34	5-3000	Air	Air	Air	
1596M-60	6000	1.25	12	1200	34	5-3000	Air	Air	Water	
TA 1696M-60	6000	1.25	12	1200	36	dc-3000	Water	Air	Water	
TA 1600M-80	8000	1.25	16	3000	90	dc-3000	Water	Air	Water	
TA 3200M-100	10000	1.25	16	3000	90	dc-3000	Water	Air	Water	
TA 13500-120	12000	1.25	16	3000	90	dc-3000	Water	Air	Water	
TA 165-165	16500	1.25	16	3000	95	5-3000	Water	Air	Water	
TA 1100D-220	20000	1.25	16	3000	95	5-3000	Water	Air	Water	

Systems with TA in model number include all silicon, direct coupled, solid state power amplifiers.

MULTIPLE SHAKER SYSTEMS FOR LARGE LOADS, HIGH FORCE RATINGS, OR SPECIAL APPLICATIONS ARE AVAILABLE

Accessory instruments

Shaker system controls and protective functions



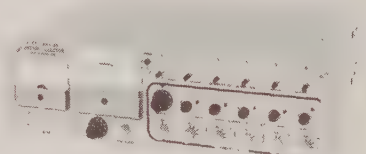
MULTIFUNCTION AVERAGING CONTROL
Model MAC-6C

Features: Phase insensitive averaging for at least 6 inputs ■ Allows averaged shaker system control for sine and random tests ■ Sine tests: absolute average of output yields average of input magnitudes ■ Random tests: spectral density of output yields average of input spectral densities ■ Freedom from detector time constant problems ■ DC output for recording ■ Units may be coupled for more than 6 inputs



SERVO PROGRAMMERS
Models SP5 and SP2

Features: Combines functions of amplitude servo and vibration programmer in one instrument ■ Programmer contains up to five program segments with servo controlled acceleration, velocity or displacement selectable for each segment (SP5) ■ Simplified closed-loop presetting of vibration levels before actual test is performed ■ Optional safety shutdown at pre-set level of acceleration ■ Solid state, plug-in, printed circuit construction ■ Log dc output for X-Y recording of test



ACCELERATION CONTROL SELECTOR
Model ACS-6

Solid State Switching

Features: Automatically switches to highest (or lowest) accelerometer for amplitude servo control ■ Up to 6 input acceleration signals ■ Switching speed continuously variable with frequency ■ Weighted switching from .01 to 10 times nominal acceleration ■ Wide dynamic range ■ Pilot light indicates controlling channel.



Calibration systems for accelerometers

AUTOMATIC CALIBRATION SYSTEMS

Unholtz-Dickie automatic calibration systems, based on Model 106A shaker automatically plot accelerometer calibration curves of charge or voltage sensitivity vs. frequency to any level up to 100 g and 10 kHz. Original data is permanently plotted — eliminating operator error in readout and transcription. Continuous curve detects all variations, expansion or compression of vertical scale for optimum accuracy and readability of curves. One per cent accuracy of unknown accelerometer relative to reference.

ABSOLUTE CALIBRATION OPTICAL SYSTEM

Model DO-5000. New optical instrument gives digital readout of absolute displacement.

Piezoelectric accelerometers



Micro-miniature
0.8 grams
General purpose
high sensitivity

For accurate vibration measurements this D21 series of shear mode types insure freedom from case sensitivity and lowest cross axis sensitivity. A range of sizes covers most applications, down to a 0.65 gram sub-miniature model. This series uses Lead Zirconate-Titanate crystals. Also available are Bismuth composition crystals for high temperatures.

Tracking Filter \$900.00

Bandwidth: fixed or 10% of center frequency.

Outputs: filtered AC at unity gain and DC proportional to log of filtered AC.

Mounting: use separately or with up to six in 11RA Rack Adapter

Model TF11



UNHOLTZ-DICKIE CORP.

3000 Whitney Ave. Hamden, Conn. 06518

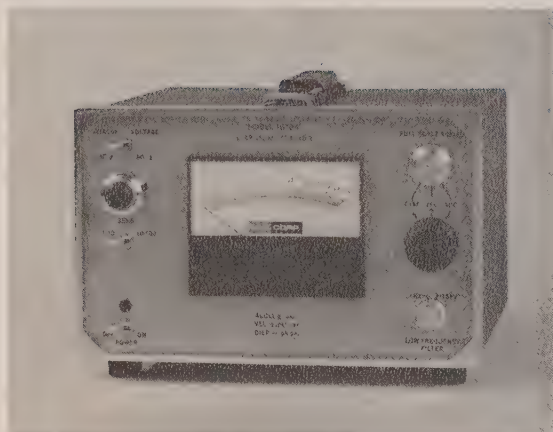
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BULLETIN 1B-71S-1

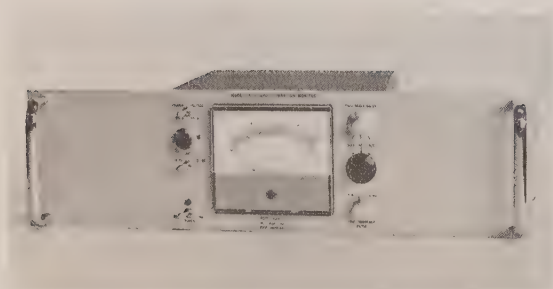
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vibration generation systems and measurement instruments



Model 1610M

\$795.00



Model 1610RMT

\$775.00



Model 2610RMT

\$1,550.00

MODEL 1610 SERIES

DOUBLE INTEGRATING CHARGE/VOLTAGE MONITOR for indicating and recording of acceleration, velocity or displacement from a piezoelectric accelerometer. Has $4\frac{1}{2}$ " meter with log scale.

Outputs include 10 mV/g normalized acceleration, 100 mV/in./sec. normalized velocity, 1 V/in. DA normalized displacement, 1 V rms full scale that is switch selectable to represent acceleration, velocity or displacement.

Front panel locking toggle switch selects "charge" or "voltage" type amplifier. Direct dialing of accelerometer sensitivity from 1 to 100 pC or mV/g. Low noise input circuitry provides 80 dB dynamic range, and selection of acceleration, velocity or displacement readout in sets of 4 decade ranges.

OPTIONAL FEATURES

Option "G" — variable gain galvo output adjustable with a multiturn potentiometer from 0 to 5 V pk full scale or 85 mA rated current into load of 10 ohm

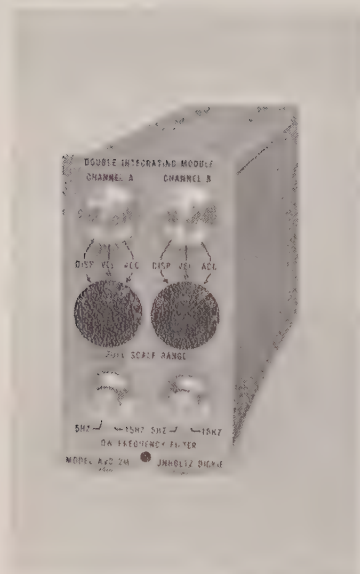
Price.....\$65.00

Option "F" — linear DC output

Price.....\$25.00

Option "L" — log DC output. Single ended DC output proportional to the logarithm of the average value of the selected output signal.

Price\$175.00



AVD-2M

\$590.00

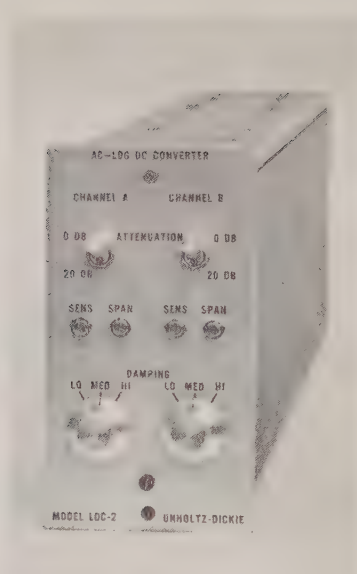
Provides double integration of conditioned 10 mV/g acceleration signals in each of 2 channels. Four outputs from each channel include normalized velocity at 100 mV/in./sec, normalized displacement at 1 V/in. DA, a 1 V rms full scale output for tape recording, and a DC output for meter or X-Y plotter. Wide dynamic range of 80 dB; convenient decade ranging of switchable outputs; and sharp cutoff low frequency filters are provided.



CV11M-LF1

\$625.00

Accelerometer signal conditioning charge or voltage amplifier, operating down to 0.1 Hz. Special low noise and low drift for low level with full scale ranges as low as 0.1 g. Combines low level, low frequency vibration measuring capabilities with capability of measuring shock pulses with relatively long durations.



LDC-2

\$530.00

Provides conversion of conditioned 1 V peak input signal to log DC for X-Y recording in each of 2 channels. Features include a 60 dB dynamic range, ± 0.5 dB conversion linearity, ± 0.5 dB flatness from 5 Hz to 10 kHz, and selectable damping. The two channels can be connected directly to the (+) and (-) inputs of a differential input X-Y recorder to obtain ratio plots such as transmissibility.

SPECIFICATIONS AVAILABLE ON REQUEST
All prices f.o.b. factory, Hamden, Connecticut

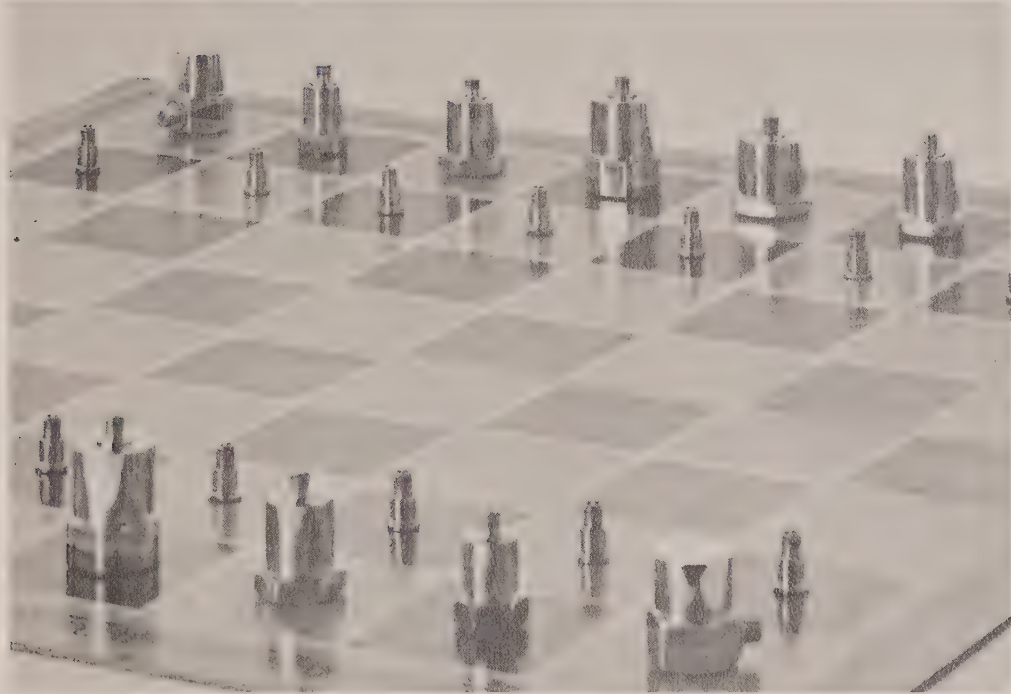
UNHOLTZ-DICKIE CORPORATION

3000 Whitney Avenue, Hamden, Connecticut 06518

Area Code (203) 288-3358

Bulletin INS-71
Printed in U.S.A.

ACCELEROMETERS



A full line of piezoelectric self-generating accelerometers are produced by Unholtz-Dickie for general purpose vibration testing and for special applications. Various models are optimized to provide features such as subminiature size, high sensitivity, high frequency operation, high temperature operation, and normalized 10 pC/g sensitivity for special applications.

Unholtz-Dickie accelerometers operate over wide acceleration and frequency ranges. Typically, accelerations from a fraction of a g to 1000 g's may be sensed, and upper frequency limits of 4 kHz to 12 kHz are attainable. Special design features limit case and base strain sensitivities.

Unholtz-Dickie also offers a wide range of signal conditioning charge and voltage amplifiers for use with piezoelectric accelerometers. Conditioned signals are produced for servo control purposes, for direct recording, for log-log frequency response plotting, and for meter indication of acceleration, velocity, or displacement. Special circuit features allow very low frequency operation with piezoelectric accelerometers.

NEW

The Model 10B10 is factory adjusted to exactly 10.0 pC/g charge sensitivity. Data acquisition is greatly simplified using this standardized output.

NEW

ACCELEROMETERS

MODEL	PERFORMANCE FEATURES	NOMINAL					DESIGN FEATURES	PRICE EACH *
		OPEN - CIRCUIT VOLTAGE SENS. mV-pk/g-pk	CHARGE SENSITIVITY pC-pk/g-pk	USEFUL FREQUENCY RANGE-Hz	MOUNTED RESONANT FREQUENCY-KHz	SIZE-INCHES WEIGHT-GRAMS		
2E3	Subminiature, extremely small, light-weight, for highest frequencies and minimum added mass.	2.5	1.0	1.0 TO 12000	70	HT .310 DIA .220 WT 1.22	Shear, side connector, integral cable, molded neoprene strain relief boot, adhesive mount, lead zirconate-titanate crystal. 2E5 has wrenching flats for easy removal.	\$213.00
2E5	Relatively large voltage and charge outputs. Low base strain sensitivity construction.					HT .310 DIA .280 WT 1.36		
2D21	Subminiature, lightweight, with low base strain sensitivity construction. Removeable cable.					HT .415 DIA .280 WT 1.31	Shear, top connector, wrenching flats for easy removal, lead zirconate-titanate crystal.	
5D21-8	Miniature, general purpose, moderately high resonance, low base strain sensitivity, recommended for charge use.	5.0	8.0	0.2 TO 7000	40	HT .64 HEX .50 WT 10.7	Shear, top connector, 10-32 mounting hole, lead zirconate-titanate crystal. Stainless steel case.	\$185.00
5D21	Miniature, general purpose, similar to 5D21-8. Low base strain sensitivity.	8.7	14			HT .64 HEX .50 WT 13		
10DQ21	General purpose, side connector for restricted height applications. Low base strain sensitivity.	20	40	0.2 TO 6000	30	HT .71 HEX .62 WT 25	Shear, side connector, 10-32 mounting hole, lead zirconate-titanate crystal. Stainless steel case.	
20D21	General purpose, top connector, recommended for voltage use with 35 foot low noise cables. Low base strain sensitivity.	22	35	0.2 TO 6000		HT .71 HEX .62 WT 23	Shear, top connector, 10-32 mounting hole, lead zirconate-titanate crystal. Stainless steel case.	\$220.00
75D21	Maximum voltage and charge sensitivity gives best signal/noise ratio for low level measurements. Low base strain sensitivity.	75	82	0.3 TO 4000	20	HT .74 HEX .75 WT 37		
8B6	Wide temperature range, - 300°F to +500°F, flat voltage and charge sensitivities. Stainless steel case. Recommended for calibrator.	2.9	7.5	1.0 TO 5000	30	HT .88 DIA .76 WT 36	Double base, compression, top connector, 10-32 mounting hole. Bismuth strontium-titanate crystal. Stainless steel case.	\$225.00
10B10	Charge sensitivity normalized at 10 pC/g. Wide temperature range, - 300°F to +500°F. Flat voltage and charge sensitivities. Low base strain sensitivity.	3.1	Set at exactly 10.0	1.0 TO 4000	25	HT .78 HEX .62 WT 27	Double base, compression, side connector, 10-32 mounting hole. Bismuth strontium titanate crystal. Stainless steel case.	\$235.00
10B10T						HT .81 HEX .62 WT 29.5	Same as 10B10. but with top connector.	\$250.00
A-1 Probe	General purpose hand - held accelerometer for vibration survey.	3.5	5.2	0.3 To 600 (hand-held)	NA	LGH 5.25 DIA .62	Shear mode, hand - held, aluminum case with stainless steel tip	\$250.00

UNHOLTZ-DICKIE CORPORATION

3000 Whitney Avenue, Hamden, Connecticut, 06518

Area Code (203) 288-3358

Bulletin ACC-72
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UNHOLTZ-DICKIE CORPORATION

Test Equipment and Instrument Inspection and Shipping Instructions

1. Unpacking and Inspection

If the shipping carton is damaged, note on acceptance that it is received damaged and subject to claim when inspected. Ask that the carrier's agent be present when the instrument is unpacked and inspected for damage (scratches, dents, broken knobs, etc.) If the instrument is damaged or fails to meet specifications, notify the carrier and the Unholtz-Dickie Corporation immediately. Retain the shipping carton and the padding material for possible return for repair or further inspection by carrier. The purchaser and Unholtz-Dickie Corporation will arrange for the replacement and/or repair of the damaged item.

Refer to our separate warranty page for a statement of our warranty policy.

2. Storage and Shipment

Return Shipment Procedure: Please be sure the following instructions are observed if for any reason the item is being shipped back to Unholtz-Dickie for repair or replacement.

- A. Packing: To protect valuable electronic equipment during storage or shipment, always use the best packaging methods available. Unholtz-Dickie can provide packing material such as that used for original factory packaging. Contract packaging companies in many cities can provide dependable custom packaging on short notice. Here are a few recommended packaging methods:
- (1) Original - Place instrument in original container. Replace all packing pads and fillers in the exact position which they originally occupied. If original packing is no longer available, use 2 inch thick foam rubber padding.
 - (2) Rubberized Hair - Cover painted surfaces of instrument with protective wrapping paper or plastic bag. Pack instrument securely in strong corrugated container, double wall (350 lb/sq.in. minimum bursting test) with 2-inch rubberized hair pads placed along all surfaces of the instrument. Insert fillers between pads and containers to ensure a snug fit.
 - (3) Excelsior - Cover painted surfaces of instrument with protective wrapping paper or plastic bag. Pack instrument in strong corrugated container, double wall (350 lb/sq.in. minimum bursting test) with a layer of excelsior about 6 inches thick packed firmly against all surfaces of the instrument.
- B. Environment: Conditions during storage and shipment should normally be limited as follows:
- (1) Minimum temperature: -40°F. (-40°C).
 - (2) Maximum temperature: 167°F. (75°C).
 - (3) Maximum average humidity less than 70%.

UNHOLTZ - DICKIE CORPORATION

2994 Whitney Avenue/Hamden, Conn./Area Code 203 288-3358

MP MASTER



MA34553